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The Brazilian Soybean Industry

Economic Structure and Policy Interventions

Gary W. Williams
Robert L. Thompson

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Abstract

Brazil had successfully challenged U.S. dominance as a principal soybean product supplier in the seventies by rising from virtually zero to a world share of 20.2 percent for soybeans in 1975, 45.2 percent for soybean meal in 1977, and an estimated 36.1 percent for soybean oil in 1981. This success is believed to have been largely the result of subsidies and policies favoring soybean production and exports. Brazil's prior gains are likely to be hindered by the current global recession as well as by its own domestic policies. Quantitative measurements of the key economic variables and a simulation analysis show that Government intervention policies may have had some benefits for the U.S. soybean industry.

Keywords: Soybeans, soybean meal, soybean oil, Brazil, intervention policies.

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Contents

Summary

Once the principal world supplier of soybean products, the United States has recently faced strong competition in the world markets from Brazil. Brazil's emergence in the seventies as a major soybean product exporter may be tempered by smaller gains, or possible declines, in the eighties because of domestic policy intervention by its Government and the global recession.

This report is based on a complete model of the world soybean economy, which measures the complex relationships among prices, policies, and other factors. For example, the effect of economic variables from Government intervention in the soybean industry is examined, showing that some of the policy interventions may actually have benefited U.S. soybean and product export sales.

In 1960 Brazil exported no soybeans or products. The United States, by contrast, held sizable shares of the global market: 76.3-percent soybeans, 47.2-percent soybean meal, and 71.1-percent soybean oil. The 1981 estimated figures show a far different picture. Brazil exported 44.1 percent of all soybean meal compared with U.S. shipments of 31.4 percent. Brazil's soybean oil exports amounted to a 36.1-percent share, and the U.S. share dipped to 23 percent. The United States, however, maintained a major share of soybean exports, 82.2 percent, compared with only 5.4 percent for Brazil.

A rapid expansion of Brazil's agricultural frontier coincided with a surge in world demand for soybeans and products to challenge U.S. dominance in the world soybean market. The high quality of Brazilian soybeans helped to shift buyer interest to that source. Soybeans produced in the major growing areas of Parana and Sao Paulo have a higher oil and protein content than U.S. beans. Buyers for the European crushing industry, for example, were willing to pay \$3 to \$5 more per metric ton for Brazilian beans despite their higher content of discoloring dust and free fatty acids which increased refining costs. Europeans have expressed a preference for Brazil's protein meal as well. This is because U.S. meal sometimes contains as little as 40-percent protein compared with Brazil's 47 to 48 percent.

Brazil's soybean growers also enjoy a seasonal advantage over American farmers. Their March-to-May harvest ideally fills peak-price August orders; the September/October U.S. harvest matches a post-August price drop which usually lasts until February.

Conversion chart—This report uses metric units throughout. In this report, the word ''ton(s)'' stands for metric ton(s).
1 metric ton–2,204.62 pounds
1 hectare–2.471 acres
179.39 cruzeiros= 1 U.S. dollar (1982)

The Brazilian Soybean Industry:
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Gary W. Williams and Robert L. Thompson*

Introduction

A dramatic growth in Brazilian exports of soybeans and soybean products in the seventies has greatly eroded U.S. dominance of these world markets. By 1977 Brazil exported more soybean meal and almost as much soybean oil as the United States (table 1). Two successive drought-reduced soybean crops in Brazil in 1978 and 1979 temporarily eased the competition for the U.S. soybean industry. However, with the return of good weather to Brazil's southern soybean-producing region, Brazilian soybeans and soybean products again provide keen competition for U.S. exports in foreign markets.

This report examines the economic and policy characteristics of the Brazilian soybean industry, particularly its relationship to U.S. and importing countries' soybean economies.

The Soybean Economy

Brazil produces several oilseeds, including soybeans, peanuts, cottonseed, castor beans, oiticica and babassu, and other related American palm kernels. Soybeans and soybean products dominate the market in production, use, and trade.

Soybean Production[1]

Immigrant Japanese farmers introduced soybeans to Brazil nearly 70 years ago. However, the crop remained relatively unimportant until the late sixties (table 2). Soybeans accounted for only 13 percent of the production of the three major oilseeds (soybeans, peanuts, and cottonseed) in 1960, but by 1981 soybeans accounted for over 90 percent of the total (table 3). Soybean area increased from 171,000 hectares in 1960 to 5.1 million hectares in 1974. Growing more slowly, soybean area reached about 8.8 million hectares in 1980.

Soybean production is concentrated in the southern states where it got its start; Rio Grande do Sul and Parana account for almost 75 percent (table 4). Mato Grosso displayed the most rapid recent expansion, becoming the third largest producing state in 1979.[2] Sao Paulo was a close fourth followed by Santa Catarina. Some expansion into *cerrado*, or savannah, regions of Goias and Minas Gerais has also occurred.

The bulk of the growth in production has come from increases in area, rather than increases in yield (table 2). For example, between 1960 and 1980, soybean production increased nearly 74 times when area planted advanced over 51 times, but yield increased only 1.4 times. Soybean yields varied considerably among states. Average yields in tons per hectare for the 1981 crop were as follows: Parana, 2.24; Sao Paulo, 1.90; Rio Grande do Sul, 1.59; Mato Grosso do Sul, 1.73; Santa Catarina, 1.34; and other, 1.39 *(28)*. Increases in yields to date largely reflected use of soybean varieties adapted to local conditions, improved cultural practices, and a shift onto more fertile, virgin soils. Variability in yields among states reflected basic differences in such factors as soils and climate.

Although the opening of new land became an important means of increasing soybean area, most expansion covered land used for other crops and pasture. Zockun's analysis of the period 1970–73 for the three largest

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[1] This section draws heavily on *(31)*, *(24)*, and *(27)*. Italicized numbers in parentheses cite sources listed in the References section at the end of this report.

[2] Mato Grosso was split into two states in 1979: Mato Grosso and Mato Grosso do Sul. Unless otherwise indicated, the use of "Mato Grosso" includes both states.

Table 1—Share of world exports of soybeans, meal, and oil, by major producer, 1960–81

Calendar year	Soybeans: United States	Soybeans: Brazil	Soybeans: China	Soybeans: Argentina	Soybeans: Other[1]	Meal: United States	Meal: Brazil	Meal: Argentina	Meal: Other[1]	Oil: United States	Oil: Brazil	Oil: China	Oil: Argentina	Oil: Other[2]
						Percent								
1960	76.3	—	21.3	—	2.4	47.2	—	—	52.8	71.1	—	3.6	—	25.3
1961	87.0	1.7	8.0	—	3.3	51.9	2.9	—	45.2	69.6	—	.3	—	30.1
1962	88.8	2.0	6.9	—	2.3	61.8	2.9	—	35.3	81.6	—	.1	—	18.2
1963	91.0	0.6	6.4	—	1.0	66.2	3.0	—	30.8	79.4	—	.4	—	20.2
1964	90.7	—	7.9	—	1.4	67.5	1.9	—	30.6	79.8	—	.4	—	19.8
1965	88.8	1.1	8.3	—	1.8	70.0	3.7	—	26.3	79.2	—	.3	—	20.5
1966	89.0	1.6	7.3	—	2.1	72.9	5.9	—	21.2	75.9	—	.8	—	23.3
1967	88.0	3.8	6.9	—	1.3	73.3	3.7	—	23.0	76.4	—	.6	—	23.0
1968	91.5	.8	6.5	—	1.2	71.9	6.3	—	21.8	72.1	—	.5	—	27.4
1969	90.8	3.3	5.2	—	.7	71.3	7.0	—	21.7	61.0	—	.4	—	38.6
1970	93.8	2.3	3.3	—	.6	68.4	9.8	—	21.8	60.5	.2	.2	—	39.1
1971	93.8	1.7	3.7	—	.8	66.0	14.7	—	19.3	60.5	.5	.2	—	38.8
1972	86.8	7.5	2.7	—	3.0	55.4	21.5	—	23.1	53.6	5.4	—	—	41.0
1973	84.7	11.4	2.0	—	1.9	54.5	19.5	0.2	25.8	40.7	8.5	—	2.0	48.8
1974	80.0	15.8	2.0	0.3	1.1	52.5	21.6	.2	25.7	48.0	.1	—	2.4	49.5
1975	75.8	20.2	2.0	.5	1.5	42.6	35.3	1.6	20.5	26.1	19.4	—	1.5	53.0
1976	77.8	18.5	.9	.4	2.4	41.9	37.7	1.8	18.6	28.0	27.3	—	3.5	41.1
1977	81.1	13.0	.6	3.1	2.2	34.9	45.2	2.3	17.6	36.6	23.7	.1	3.3	36.3
1978	86.3	2.7	.4	8.3	2.3	40.2	36.8	2.4	20.6	35.7	19.4	.2	2.5	42.2
1979	82.2	2.5	1.2	11.1	3.0	40.4	34.3	2.3	23.0	38.2	18.0	.1	2.5	41.2
1980	81.1	5.8	.5	10.1	2.5	39.2	36.6	1.7	22.5	34.5	23.4	.1	2.9	39.1
1981[3]	82.2	5.4	.5	8.3	3.6	31.4	44.1	2.6	21.9	23.0	36.1	—	1.7	39.2

— = Less than 0.1 percent.
[1] Primarily includes transshipments by European Community countries.
[2] Primarily includes transshipments and net exports by European Community countries.
[3] Preliminary.

Source: Calculated from data in *(5)* and *(28)*.

producing states (Rio Grande do Sul, Parana, and Sao Paulo) shows that 88.4 percent of the increase in soybean area came from land planted to other crops and pasture*(34)*. Nearly all the new land was farmed in Parana and Rio Grande do Sul. Land formerly in corn was the largest source of soybean expansion in the three states, representing 37.2 percent of the total. Over half the soybean expansion in Parana came out of corn, as did about 30 percent each in Rio Grande do Sul and Sao Paulo. In the three states, 14 percent of the increase came from former pasture land, mainly in Rio Grande do Sul, pushing beef production out of that state. Cotton and rice were the other principal sources of land for expansion in Sao Paulo, coffee in Parana, and wheat in Rio Grande do Sul.

The reason for expansion is that no crop or beef cattle could compete with soybeans in profit per hectare, especially because relative prices for crops strongly favored soybeans through much of the past decade. Government policies on coffee, wheat, and production credit have also contributed to the expansion of Brazilian soybean production.

In late 1977, Brazilian farmers increased soybean area by about 10 percent. A crop of about 12.5 to 13 million tons was projected to be harvested in April–May 1978. Because of an atmospheric quirk, however, southern Brazil, where most of the soybeans are grown, experienced the worst drought of the century. In January 1978, only about 60 percent of expected rain fell in Parana, southern Mato Grosso, and parts of Rio Grande do Sul. Isolated areas received as little as 20 percent of normal moisture *(24)*. This condition extended into February, and dropped soybean yields by more than 30 percent from the previous season. The 1978 Brazilian crop fell more than 20 percent below expected production.

Despite the poor 1978 crop, Brazilian soybean growers expanded their soybean area once again (by 6.1 percent) when they planted in late 1978 on about 8.3 million hectares (see table 2). A second consecutive drought held yields at the low level of 1978, allowing a scant 7.4-percent production increase over the disastrous 1978 crop. Acreage jumped to 8.8 million hectares the following year. The return of good weather to the region produced a record 15.1-million-ton crop in 1980, nearly 50 percent greater than the drought-reduced crop of 1979.

Most future soybean area expansion will likely occur in the central west states of Mato Grosso and Goias, and perhaps Minas Gerais, although a limited potential exists for expansion in traditional producing states. The expansion in the nontraditional areas is likely to be more difficult than it was in the southern states. Whether the longrun plateau is 20 million tons or even higher will depend on how far expansion proceeds in the central west. The *cerrado* soil of the central west is much less fertile than that of Parana and Mato Grosso do Sul where recent expansion has occurred. The soil is very acidic, and has a great capacity to tie up phosphorus in an unavailable form. Therefore, much heavier applications of fertilizer and lime will be needed to achieve comparable yields, raising production costs significantly.

Table 2—Soybean production, 1960–81

Year of harvest	Area harvested	Average yield	Production	Annual growth of production
	1,000 hectares	*Kg/hectare*	*1,000 tons*	*Percent*
1960	171.4	1,200	205.7	N/A
1961	240.9	1,127	271.4	31.9
1962	313.6	1,101	345.2	27.2
1963	339.8	950	322.9	−6.5
1964	359.6	848	304.9	−5.6
1965	431.8	1,212	523.2	71.6
1966	490.7	1,213	595.0	13.7
1967	612.1	1,169	715.6	20.3
1968	721.9	907	654.5	−8.5
1969	906.1	1,166	1,056.6	61.4
1970	1,318.8	1,144	1,508.6	42.8
1971	1,716.4	1,210	2,077.3	37.7
1972	2,840.0	1,291	3,666.0	76.5
1973	3,615.1	1,386	5,011.6	36.7
1974	5,143.1	1,531	7,876.2	57.2
1975	5,823.7	1,699	9,892.3	25.6
1976	6,417.0	750	11,227.0	13.5
1977	7,070.0	1,770	12,513.0	11.5
1978	7,778.0	1,226	9,534.0	−23.8
1979	8,255.0	1,240	10,236.0	7.4
1980	8,769.0	1,728	15,153.0	48.0
1981[1]	8,534.0	1,781	15,200.0	.3

N/A=not applicable.
[1] Estimated.

In addition to their less productive *cerrado* soils, the central west states are farther from export ports and crushing facilities and lack the necessary infrastructure to support a large expansion of soybean production and marketing. These drawbacks and the higher costs of production mean that soybean production may develop less rapidly in this region than elsewhere.

Producers in the "traditional" areas of southern Brazil may soon confront problems in maintaining yields. Severe erosion plagues Parana where soybeans are grown year-round. Weed problems are comparable to those in the U.S. Midwest, and insect control problems appear much worse. Because soybeans are still a relatively new crop, producers have not faced serious disease problems. Soybean research is rather thin, but strong measures are rapidly being taken to correct this deficiency. A National Center for Soybean Research, established in 1976 in Londrina, Parana, is working to solve these problems as well as to breed varieties better adapted for the low latitudes to the north.

Farm-to-port transport often costs four times more in Brazil than in the United States, because of Brazil's deficient railroad and water transportation. Most soybeans move from farm to port or crusher by truck in 25-ton lots, reducing prices to farmers and raising prices paid by crushers. In the early seventies, storage and port capacity were strained, forcing soybeans to be exported or moved to crushers before the wheat

Table 3—Production of soybeans, peanuts, and cottonseed, 1960–81

Year of harvest	Soybeans[1]	Peanuts[2]	Cottonseed[3]	Total	Portion in soybeans
	1,000 tons				*Percent*
1960	206	408	651	1,265	16.3
1961	271	584	759	1,614	16.8
1962	345	648	982	1,975	17.5
1963	323	604	894	1,821	17.7
1964	305	470	894	1,669	18.3
1965	523	743	817	2,083	25.1
1966	595	895	972	2,462	24.2
1967	716	751	796	2,263	31.6
1968	654	754	1,009	2,417	27.1
1969	1,057	754	1,283	3,094	34.2
1970	1,509	928	1,185	3,622	41.7
1971	2,077	945	875	3,897	53.3
1972	3,666	956	1,200	5,822	63.0
1973	5,012	590	1,152	6,754	74.2
1974	7,876	439	1,030	9,345	84.3
1975	9,892	441	905	11,238	88.0
1976	11,227	514	703	12,444	90.2
1977	12,513	324	977	13,814	90.6
1978	9,534	340	844	10,718	89.0
1979	10,236	465	1,076	11,777	86.9
1980	15,153	545	1,057	16,755	90.4
1981[4]	15,200	310	1,120	16,630	91.4

[1] Harvest in February–April.
[2] Harvest in January–February and June–July, farmers' stock.
[3] Harvest in August–January and March–June of the following year.
[4] Estimated.

Sources: *(28, 31).*

Table 4—Production of soybeans, by states, 1966–81[1]

Year	Rio Grande do Sul	Santa Catarina	Parana	Sao Paulo	Mato Grosso[2]	Others[3]	Total
				1,000 tons			
1966	483	8	83	18	2	1	595
1967	551	10	113	38	3	1	716
1968	433	15	163	39	3	1	654
1969	745	32	214	61	3	2	1,057
1970	977	53	368	90	9	12	1,509
1971	1,393	78	462	86	16	42	2,077
1972	2,496	113	790	201	32	69	3,700
1973	2,872	254	1,326	330	103	127	5,012
1974	3,870	431	2,589	522	307	157	7,876
1975	4,689	467	3,625	678	273	160	9,892
1976	5,107	410	4,500	765	290	155	11,227
1977	5,678	476	4,700	768	695	196	12,513
1978	4,568	355	3,150	745	479	237	9,534
1979	3,630	425	4,000	850	854	477	10,236
1980	5,737	719	5,400	1,108	1,439	750	15,153
1981[4]	6,088	648	5,172	1,032	1,571	689	15,200

[1] Year of harvest.
[2] Includes Mato Grosso do Sul beginning in 1979.
[3] Minas Gerais, Goias, Bahia, Espirito Santo, and Rio Grande do Norte.
[4] Estimated.

Sources: *(1, 28,* and *34).*

harvest started. In response, the Brazilian Government quickly expanded storage facilities to accommodate the entire soybean crop by 1978. All of the new storage investments have gone into the more efficient bulk facilities. A substantial fraction of storage capacity, however, is still the traditional, inefficient, general-purpose, bag-type. There is virtually no onfarm storage capacity.

Inadequate port facilities hampered soybean export volume at first. Long lines of trucks waiting to unload at the ports were common in 1977. However, newer and larger port storage and handling facilities have smoothed the export flow.

The Crushing Industry

The volume of soybeans crushed in Brazil grew markedly after 1960, approaching 1 million tons in 1970, passing 4 million tons in 1974, and jumping to 13.9 million tons in 1981 (table 5). The volume crushed of both cottonseed and peanuts has fluctuated since 1960, but has recently leveled off at between 800,000 and 1.2 million tons for cottonseed and 300,000 to 700,000 tons for peanuts. Soybean crush generally increased in tandem with crushing capacity when plants ran at 85 percent of capacity (a little over 300 days per year) until 1977, after which growth in new capacity exceeded soybean production growth. Annual crush capacity hit 15 million tons in 1979, about 18 million in 1980, and 20 million in 1981 *(27, 28).*

In the late sixties, the crushing industry included a large number of small- to medium-sized, family-owned plants that crushed cottonseed, peanuts, and castor beans. When soybean production surged in the early seventies, many of these crushers began processing soybeans as well (table 6).

Data on the number and sizes of soybean crushing firms in Brazil are somewhat dated and fragmentary at best (table 7). The total daily capacity of about 40,500 tons in mid-1977 translates to a 12.2-million-tons-per-year capacity assuming 300 days of operation per year

(24). Of the 132 plants listed by the sources, 110 processed less than 500 tons per day. Almost half were concentrated in Sao Paulo, the center of the older, established crushing plants. Rio Grande do Sul had 25 and Parana 23 of these smaller plants.

Ninety-three percent of total soybean crush capacity was in Rio Grande do Sul, Parana, and Sao Paulo. Rio Grande do Sul had 39 percent of the total, and Sao Paulo and Parana each had 25 to 30 percent. Trade sources noted the addition of three new plants crushing more than 1,200 tons per day in 1978 and another six plants in 1979.

A 1977 study by the Instituto de Pesquisas Economicas indicated that the older, smaller firms tended to be relatively inefficient, operating with outdated mechanical presses and little or no working capital *(19)*. The study examined 13 Brazilian soybean processors and found that small- and medium-capacity firms halted operations up to 6 months each year because of lack of capital for soybean buying in the between-harvest period. Many of these firms went out of business in recent years. The large firms, however, often stopped operations no more than 30 days a year for equipment maintenance and repairs. A survey by the Rio Grande do Sul Oilseed Crushers' Association in late 1977

Table 5—Crush of soybeans, peanuts, and cottonseed, 1960–81

Year of harvest	Soybeans[1]	Peanuts[2]	Cottonseed[3]	Total	Portion in soybeans
	1,000 tons				*Percent*
1960	185	347	605	1,137	16.3
1961	171	492	1,706	1,369	12.5
1962	213	532	913	1,658	12.8
1963	258	501	831	1,590	16.2
1964	274	400	831	1,505	18.2
1965	282	616	760	1,658	17.0
1966	395	749	904	2,048	19.3
1967	423	625	740	1,788	23.7
1968	471	632	994	2,097	22.5
1969	612	615	1,193	2,420	25.3
1970	932	743	1,102	2,777	33.6
1971	1,700	773	814	3,287	51.7
1972	2,132	765	1,121	4,108	53.1
1973	2,714	401	1,087	4,202	64.6
1974	4,302	308	960	5,570	77.2
1975	5,516	301	842	6,659	82.8
1976	6,374	350	654	7,378	86.4
1977	8,661	220	909	9,790	88.5
1978	8,882	230	785	9,897	89.7
1979	9,094	353	1,001	10,448	87.0
1980	13,008	432	983	14,423	90.2
1981	13,900	190	1,043	15,133	91.9

[1] Year beginning in April through 1976, after which beginning March.
[2] Calendar year (farmers' stock).
[3] Crush from the August-January harvest of the preceding year and the March–June harvest of the given year.

Sources: *(28)*, except peanuts data (1960 to 1972 only), which is based on the following formula: 0.85 x (production minus exports), and cottonseed data (1960 to 1972 only) which is based on following formula: 0.93 x (production plus imports).

Table 6—Daily installed oilseed crushing capacity, by type of oilseed crushed in the southern region of Brazil, 1974

Type of oilseed crushed	Installed capacity in the vegetable oil industry			
	Sao Paulo	Parana	Rio Grande do Sul	Total
	Percent			
Soybeans	3.3	53.9	100.0	48.9
Soybeans/peanuts	31.6	23.0	*	18.8
Soybeans/peanuts/castorbeans	7.6	*	*	3.1
Soybeans/cottonseed	22.0	*	*	8.8
Soybeans/cottonseed/peanuts	10.2	15.6	*	8.8
Soybeans/cottonseed/peanuts/corn	2.8	*	*	1.1
Soybeans/corn	.5	*	*	.2
Cottonseed	2.3	4.4	*	2.1
Castorbeans	1.5	3.1	*	1.4
Corn	9.3	*	*	3.7
Peanuts/castorbeans	1.5	*	*	.6
Cottonseed/peanuts	5.5	*	*	2.2
Castorbeans/peanuts/cottonseed	1.9	*	*	.8
Total	100.0	100.0	100.0	100.0
Total soybean capacity	78.0	92.5	100.0	89.7

*=less than 0.1 percent.

Source: (*34*, p. 23).

Table 7—Soybean crushing capacity, by size of firm and state, 1977

Plant capacity	Rio Grande do Sul	Parana	Sao Paulo	Minas Gerais	Santa Catarina	Brazil total
Under 499 tons:						
Number of firms	25	23	51	3	8	110
Total capacity (tons per day)	3,822	4,342	7,345	585	1,520	17,614
500–999 tons:						
Number of firms	6	4	2	0	1	13
Total capacity (tons per day)	4,320	2,600	1,400	0	600	8,920
Over 1,000 tons:						
Number of firms	5	3	1	0	0	9
Total capacity (tons per day)	7,500	5,150	1,350	0	0	14,000
Totals:						
Number of firms	36	30	54	3	9	132
Total capacity (tons per day)	15,642	12,092	10,095	585	2,120	40,534

Source: *(24)*.

showed that all plants built in that state in 1977 used continuous solvent extraction *(24)*. Of 20 existing firms that expanded their capacity in 1977, 9 chose this system and 5 others went to a mixed system, either with prepress followed by solvent extraction or batch pressing by solvent.

International production cost comparisons are difficult, but certain qualitative comparisons between Brazil and the United States were made for 1977 on the basis of interviews with trade sources *(24)*. These comparisons are based on official mid-1977 exchange rates. Despite a higher labor input per ton of production, lower wage rates made the total labor cost per ton less than that in the United States. The solvent (hexane) cost was much higher per ton in Brazil than in the United States, partly because of higher solvent losses from using a lower quality solvent, which was more difficult to recover.

Another cost disadvantage to the Brazilian crusher was the need to absorb the cost of a full-time staff of maintenance personnel to prevent breakdown because of otherwise unavailable mechanics, plumbers, and electricians, and the larger spare parts inventory which had to be carried. Overall, the variable cost of soybean crushing in a comparable-size plant was slightly higher in Brazil than in the United States.

The recent increased crush capacity, 1,200 to 2,000 tons per day, has concentrated in Rio Grande do Sul and Parana, an area between soybean-producing areas and export ports. Although only eight large plants showed up in the 1977 data, their total capacity exceeded that of the 48 small firms (under 500 tons per day) in those two states. Most new plants built in the last 5 to 7 years were financed by multinational firms which supplied their own capital. Brazilian firms, particularly cooperatives, that have expanded or established crushing operations, have received subsidized loans for capital investment. Most likely, the crushing industry has expanded because of a strong world market for soybeans and products coupled with export policies favoring processed products over raw soybeans.

Oil and Meal Markets

The domestic disappearance of the three major oils (soybean oil, peanut oil, and cottonseed oil) in 1981 hit about 1.6 million tons, a 730-percent increase from 1960 (table 8). Soybean oil consumption jumped more than fiftyfold during the same period, peanut oil consumption dropped considerably, and cottonseed oil consumption remained at about the same level. Urban areas consumed most soybean oil.

Margarine consumption also grew rapidly, possibly replacing butter to some extent. The annual production of margarine required an estimated 370,000 tons of oil, mostly from soybeans. Margarine producers in Brazil are required by law to include not less than 5-percent cottonseed oil *(24)*; as a result, 50 to 75 percent of the relatively small cottonseed oil production in Brazil goes into margarine, and the remainder is exported *(27)*.

Declining peanut and cotton production in Brazil in recent years, combined with the closing of some small, general-purpose oilseed-crushing plants, led to reduced production of peanut and cottonseed oil. In 1981 Brazil produced 54,000 tons of peanut oil, exporting 50,000 tons and leaving only 4,000 tons for the domestic market. Cottonseed oil production reached about 173,000 tons, but only 93,000 tons were consumed domestically; nearly all the corn oil, about 36,000 tons, was consumed domestically. Lard production and consumption totaled about 210,000 tons each. In contrast, soybean oil consumption reached 1.5 million tons.

Despite domestic shortages, cottonseed oil is exported to take advantage of a substantial premium over soybean oil prices on the world market. By retaining more soybean oil for the domestic market and exporting more cottonseed oil, total export revenue is increased. Peanut oil production, despite substantial domestic demand, has been squeezed by the smaller plantings of peanuts and by shipment of more peanuts as nuts. The premium paid for peanut oil on the export market causes 85 to 95 percent of production to be exported.

All the large soybean-crushing firms are oil refiners and canners as well, because firms are permitted to export oil only if they also sell domestically. This encourages crushers to be refiners; yet 30 percent of domestic oil consumption is still supplied by the small, traditional crushers *(24)*. The remaining 70 percent is supplied by larger, newer plants, two of which manufacture margarine.

The demand for oilseed meals in Brazil evolved from mixed feed demand. More than 75 percent of the meal consumed went into poultry rations, 16 percent to swine, and most of the rest to dairy cattle *(3), (34)*. Little meal was fed to beef cattle. Meal consumption, which had been growing relatively slowly, took off in 1973 (table 8). Consumption reached 653,000 tons then, six times the consumption of 1960. By 1981 volume had quadrupled, reaching 2.5 million tons, on an average annual rate of increase of nearly 30 percent between 1977 and 1981.

The principal sources of protein in feed had been cottonseed meal and peanut meal, supplemented by meat meal, bone meal, fish meal, blood meal, and the like. The growth in soybean meal availability, the decline in its price relative to other meals, and the rapid growth of the Brazilian poultry industry which began about 1970 led to the rapid increase in soybean meal consumption. Today soybean meal is the preferred protein feed supplement and constitutes about 25 percent by volume of livestock feed rations produced in Brazil *(24)*.

Table 8—Domestic disappearance of three major oils and meals, 1960–81

	Soybean[1]		Peanut[2]		Cottonseed[3]		Total	
Year	Oil	Meal	Oil	Meal	Oil	Meal	Oil	Meal[4]
				1,000 tons				
1960	29	111	97	81	91	293	217	440
1961	27	68	138	79	104	325	269	420
1962	36	79	151	124	138	442	325	576
1963	41	93	132	87	121	374	294	494
1964	44	120	112	128	140	381	296	572
1965	52	64	173	118	119	371	344	498
1966	72	56	210	137	140	417	422	548
1967	82	149	167	96	108	336	357	529
1968	84	95	177	144	149	409	410	588
1969	100	102	170	105	179	413	449	554
1970	162	105	176	89	164	378	502	511
1971	291	190	158	100	122	267	571	519
1972	339	64	137	128	168	383	644	519
1973	435	653	68	74	161	429	664	1,084
1974	675	915	54	44	143	384	872	1,276
1975	702	810	46	80	117	394	865	1,219
1976	800	847	4	47	85	317	889	1,157
1977	1,044	1,358	13	37	114	423	1,171	1,742
1978	1,060	1,567	4	36	104	362	1,168	1,901
1979	1,300	1,993	19	51	133	432	1,452	2,400
1980	1,450	2,538	8	65	114	513	1,572	3,027
1981	1,500	2,500	4	35	80	543	1,584	2,979

[1] Year beginning April through 1976 after which beginning March.
[2] Year beginning January.
[3] Year ending July.
[4] In soymeal equivalents.

Source: *(28)*.

Brazil's poultry industry underwent a major modernization during 1965–75. The broiler industry responded to rising incomes and meat demand. For example, Brazilian Poultry Producers Association data show that broiler production grew from 154,000 tons in 1969 to 1.25 million tons in 1980. Egg production grew rapidly during 1969–72, leveled off at around 500 to 550 million dozen per year in the midseventies, and then jumped to 800 million dozen by 1980 *(27)*.

As the poultry industry grew, the demand for high-protein feed supplements increased as well. Modernization of the Brazilian swine industry has begun, and the potential demand for swine rations is large. Pork production increased 20 percent from 834,000 tons in 1977 to 1 million tons in 1980 *(27)*. Given the right economic incentives, the swine and dairy industries also could change rapidly during the eighties, substantially increasing demand for soybean meal.

Soybean and Products Trade

The phenomenal growth of the soybean industry is directly related to the export market for soybeans, soybean meal, and soybean oil. Exports of peanuts, cottonseed, and their derivatives have always been small (table 9). Soybean exports, however, increased from 310,000 tons in 1969 to over 1 million tons in 1972 and peaked in 1975 at 3.5 million tons. Exports were restricted to about 659,000 tons in 1978 and to 638,000 tons in 1979 because of domestic supply shortages after 2 years of severe drought. Soybean imports, on the other hand, rose dramatically after 1978 under an import drawback scheme for the re-export of the products.

Brazil rapidly established a reputation for exporting high-quality soybeans during the sixties. Once Brazil became a serious and regular supplier, a preference for Brazilian soybeans ensued; beans grown in Parana and Sao Paulo reportedly have a higher oil and protein content than those grown in the United States (*24*). Meal made from Parana soybeans reportedly contained 47-percent protein compared with a maximum of 45 percent from Rio Grande do Sul and even less from U.S. beans. The oil yield from Parana and Sao Paulo beans is more than 18.5 percent compared with about 17.7 percent from U.S. beans. European crushers were reportedly willing to pay $3 to $5 per ton more for Brazilian than U.S. beans in mid-1977 *(24)*.

Brazilian soybeans have at least one major drawback: according to European crushers, the free fatty acid content of crude soybean oil is higher than in oil from U.S. beans and costs more to refine. One Brazilian crusher suggested that higher humidity in Brazil requires more careful storage and more drying of soybeans *(24)*. Also, red dust, which normal cleaning fails to dislodge from Brazilian beans, often gives a reddish color to the oil. This requires more bleaching clay in refining. In any case, these complaints appear not to have dampened the preference of importers for Brazilian soybeans.

Brazilian soybean meal is preferred by importers. It is generally pelleted at the crushing plant, partly as a pollution control device. European feed compounders prefer the pelleted meal over powder, other things being equal. But more important, the Brazilian meal is 47- to 48-percent protein-guaranteed. U.S. meal is sold as 44-percent protein. Some European importers have complained that U.S. meal frequently contains as little as 40-percent protein because of hulls that are filled back into the meal. European feed compounders, who use linear programming to determine the ingredient composition of their rations, include U.S. and Brazilian meal as separate ingredients. Brazilian meal apparently is frequently chosen over U.S. meal on a cost per unit of protein basis *(24)*.

Brazilian soybeans also enjoy a seasonal advantage because they are harvested from February to May, and U.S. soybeans are harvested in September and October. The world market soybean price generally peaks about August. The price drops from then until around February, after which it increases until August. Brazil harvests its crop and begins exporting just as the price tends to rise toward its seasonal peak. Brazilian exports begin slowly in March or April, quickly accelerate through July and August, the heaviest months, and then taper off again by October or November when new-crop U.S. soybeans reach the export market.

The 1973 U.S. soybean export embargo helped to stimulate Brazilian exports. The resulting runup in soybean prices provided an additional incentive for area expansion. The embargo may have prompted some traditional U.S. customers to diversify their source of soybeans and soybean products. Brazil was the only fitting alternative.

Brazilian soybean oil exports rocketed in 1975, when the Government said that domestic soybean oil supplies were more than sufficient to satisfy domestic demand at the established ceiling price. Soybean oil exports jumped from 16,000 tons in 1974 to 560,000 tons in 1977, or 24 percent of world exports. After dropping to 332,000 tons in the drought years, exports hit 1.2 million tons in 1981 to gain over 33 percent of total world exports. Soybean meal exports showed sustained and rapid growth, when in 1981, they totaled 8.3 million tons, or more than 40 percent of world trade.

The drought-reduced crop of 1978 left some crushing capacity unused, forcing the Government to limit exports of beans. That year, Brazil imported 77,000 tons of soybeans from the United States and 200,000 tons from neighboring countries just to satisfy export commitments.

Domestic soybean crush totaled about 8.9 million tons in 1978, putting meal production at about 6.9 million tons and oil production at about 1.6 million tons. Domestic meal and oil consumption reached about 1.6 and 1.1 million tons, respectively, leaving about

Table 9—Net exports of three major oilseeds and products, 1960–81

	Oilseeds			Oils			Meals		
Year	Soybeans[1]	Peanuts[2]	Cottonseed[3]	Soybeans[1]	Peanuts[2]	Cottonseed[3]	Soybeans[1]	Peanuts[2]	Cottonseed[3]
					1,000 tons				
1960	—	—	—	—	—	—	—	54	3
1961	73	7	—	—	—	2	35	113	21
1962	97	31	—	-3	-2	-1	49	84	5
1963	33	21	—	-1	8	4	62	108	33
1964	—	—	—	-2	—	-15	44	28	26
1965	75	26	—	-9	—	-5	105	122	1
1966	121	20	—	-11	—	-4	185	155	26
1967	305	22	—	-15	8	3	125	148	27
1968	66	14	—	-9	—	—	235	103	78
1969	310	44	—	-3	2	—	310	135	172
1970	290	76	—	-2	32	1	580	201	162
1971	229	51	—	-4	58	—	990	201	132
1972	1,018	80	-2	37	77	—	1,506	170	166
1973	1,783	78	-17	82	44	2	1,373	80	104
1974	2,856	72	-2	16	32	1	2,396	75	86
1975	3,516	75	—	320	38	9	3,450	36	19
1976	3,328	30	—	430	94	13	4,078	88	3
1977	2,581	36	—	560	49	22	5,329	48	22
1978	570	20	—	522	61	14	5,368	53	23
1979	385	26	—	332	81	35	5,038	86	30
1980	1,058	38	—	935	122	50	7,212	102	50
1981	440	43	—	1,200	50	93	8,310	44	44

— = Less than 1,000 tons.
[1] Year beginning April through 1976 after which beginning March.
[2] Calendar year.
[3] Year ending July.

Sources: *(8, 28)*.

5.4 million tons of meal and 522,000 tons of oil available for export. Although soybean exports were severely restricted, and despite the drought, crushing and exports continued to increase. Following the drought of 1979, bean exports were again severely reduced, which, along with some reduction in meal and oil exports, allowed for expansion of the crushing as well as domestic consumption of oil and meal. Despite a nearly 5-million-ton increase in soybean production in 1980, bean exports increased by less than 900,000 tons, marking a record crush and higher domestic disappearance and exports of meal and oil.

Government Market Interventions[3]

Brazil maintains three general classes of policies affecting the soybean economy: production policies, domestic oil and meal consumption policies, and export policies.

Production Policies and Programs

Just before the planting season each year (around August), the Brazilian Government announces minimum support prices for all crops including soybeans. The minimum price of soybeans has always been set much below the market price so that its effect on soybean production has been minimal (table 10). However, the minimum price for corn is much closer to its market price, and changes in corn prices affect the mix of corn and soybean area planted. As part of a Government program to encourage corn production, the 1982 crop minimum price for corn was increased by more than the minimum price for soybeans, causing a shift of soybean area to corn in Parana and Rio Grande do Sul.

The Government's main encouragement for agricultural production has been its farm credit program, which permitted a small producer to borrow up to 100 percent of the basic cost of production at interest rates about half the prevailing rate of inflation. Medium and large farmers were limited to borrowing 70 and 50 percent, respectively, of the basic production cost established by the Government. Farmers in the south could borrow at a 45-percent annual interest rate, and those in the northeast at 35 percent. As inflation runs above 90 percent, such interest rates prove a sizable subsidy to farmers. Similar credit has been available in the past for the purchase of equipment and in some cases land.

These attractive credit terms led to large equipment purchases and expanded production throughout the seventies. But by 1981 the Government cut back credit to control inflation. First, the credit for new equipment purchases was severely limited. Then the average increase in the officially estimated cost of production, which was used as a basis for determining the amount of credit, was limited to 62 percent in 1981 and 88 percent in 1982. With inflation at over 90 percent in both years, this represented a substantial reduction in credit in real terms.

This change in credit policy may lead to a reduction of yields for all crops because of declining input use and

[3] For a description of general Brazilian agricultural and trade policies, see (22).

Table 10—Minimum support price of soybeans and the market price received by farmers, 1967–83

Year of harvest	Minimum support price[1]	Market price received by farmers
	Cruzeiros/ton	
1967	145.00	214.67
1968	191.30	277.00
1969	170.50	340.83
1970	213.67	421.50
1971	285.33	549.67
1972	413.33	606.83
1973	500.00	1,203.67
1974	600.00	1,175.33
1975	1,000.00	1,332.21
1976	1,250.00	1,839.46
1977	1,600.00	2,800.00
1978	1,870.00	3,572.67
1979	2,500.00	6,000.00
1980	[2]7,340.00	9,930.00
1981	11,000.00	17,835.00
1982	15,750.00	na
1983	30,000.00	na

na=not available.
[1] Announced in July or August before planting season.
[2] Originally announced at Cr$5,250 per ton. This was increased in February 1980 to Cr$7,340 per ton for those farmers selling their beans to the Federal Acquisition Program (AGF). However, the original minimum price remained the basis for extending precommercialization loans (EGF) to farmers.

Sources: *(2, 27).*

deteriorating farm machinery. Because the reduction in credit has been relatively greater for soybeans than competing crops such as corn and dry beans, soybean acreage also may decline.

Policies on other commodities, principally coffee and wheat, have also had an impact on soybeans. Excess world coffee production during the sixties prompted the Government to pay farmers to uproot old coffee trees and plant other crops, mostly soybeans. Increased world demand for coffee and repeated frost damage to coffee trees in Brazil have halted this crop substitution program.

Brazil's wheat policy has been the greatest boon to expanded soybean production. In many areas, wheat and soybeans are double-cropped. For many years, the Government protected wheat farmers through high support prices (relative to world market prices). The Government sought self-sufficiency in wheat. However, favorable soybean prices, the prospect of double-cropping, and subsidies for machinery and input acquisition stimulated the production of soybeans more than that of wheat. The same machinery can be used for both crops, and the fertilizer residual after the wheat harvest is beneficial to the soybeans.

Domestic Consumption Policies

The edible oil supply has rarely satisfied demand; during the fifties and sixties, the country relied principally on cottonseed and peanut oils and lard to satisfy domestic demand. Urbanization and rising per capita incomes increased the demand for fats, which shifted from lard to vegetable oils. These pressures rapidly escalated the price of soybean oil. In an effort to contain the rate of inflation, the Interministerial Commission on Prices (CIP) maintained wholesale and retail price ceilings on many food items, especially politically sensitive ones like vegetable oil. Periodic soybean oil shortages have occurred at the ceiling price when not enough was produced, or when the crushing industry refused to sell its inventory in an attempt to force CIP to raise the ceilings. Because of extreme domestic shortages, the soybean oil price ceilings were eliminated in February 1981. Wholesale soybean oil prices reportedly jumped by 25 percent in 2 months. Ceiling prices were maintained on soybean meal until April 1981.

Export Policies

Frequent adjustments in export taxes, subsidies, quotas, and other programs are made to maintain close control of exports of soybeans, soybean meal, and soybean oil. The objective clearly is to assure adequate supplies of oil and meal to the domestic market, stimulate use and expansion of domestic crushing capacity, and export soybean meal and oil instead of beans. Until 1981 the general policy maintained domestic price ceilings on meal and oil prices and established export quotas to prevent prices from moving above the ceilings. Moreover bean exports were controlled to ensure a positive crushing margin to the industry. Maximum quotas on the export of beans, meal, and oil, occasionally fine-tuned by differential taxes and subsidies, were established for each marketing year. These export quotas, in effect, determined the profitability of crushing and the attractiveness of investments in crushing facilities. The 1982 crop year found the export quota system abolished. However, the complicated system of export taxes, subsidies, and other programs was left intact. Under the new export system, traders can import or export soybeans and products unencumbered by the bureaucratic quota procedure. Export restrictions are imposed from time to time, however, to ensure adequate supplies for the rapidly growing domestic oil and meal markets.

Brazilian exports of all goods stagnated during the fifties and early sixties, apparently because of a restrictive Government policy toward exports *(21)*. The cruzeiro was overvalued and adjusted slowly to compensate for the country's inflation, in part to take advantage of the inelastic export demand for coffee, to restrict exports, and to reduce inflationary pressure on domestic food costs. The Government's bias against exports was also reflected in its "exportable surplus" approach to trade *(21)*. The Government determined if the domestic market had been adequately supplied, designating the surplus or remaining commodities for export. The criterion for "adequacy" was measured by the level of the domestic price. Export licenses were often denied if the domestic price increased, a procedure frequently employed.

Around 1958 soybean exports came under the control of CACEX, the foreign trade office of the Bank of Brazil. All export sales contracts had to be delivered to CACEX within 3 days of the time they were made. If the bank judged that the contract price compensated farmers fairly, it registered the sale and issued a

license; if not, the sale was rejected. The bank frequently used this procedure to slow the rate of soybean exports.

Foreign trade policy gradually shifted to one of export promotion beginning in 1964. Licensing requirements on all goods were eliminated. Beginning in 1967, the exchange rate moved closer to equilibrium with other world currencies through small and frequent devaluations consistent with the internal rate of inflation. Exports of many goods, including soybeans, began to increase, but for every 3 tons of soybeans exported, 1 ton had to be sold domestically either as beans or the meal equivalent, generating an incentive to expand the more profitable crushing industry. A 12.5-percent value-added or sales tax was levied on soybean exports. A soybean meal retention scheme established the export-domestic sales ratio at 4 to 1. The sales tax on meal exports was 5 percent and zero on domestic meal sales. The lower tax rate on exported meal compared with exported beans gave added incentive to crush the beans and export the meal. Before 1975 exports of soybean oil were essentially prohibited.

When world soybean and product prices climbed substantially above historical levels in 1972, the Brazilian mixed feed industry demanded relief, arguing that it could no longer pay the escalating prices of meal while having to sell its output at the price ceiling fixed by the Government. In response CACEX established a retention system of quotas on soybean and soybean meal exports in early 1973.

The consumer price of soybean oil was fixed by the Price Commission from 1964 through 1981. Because Brazil failed to produce enough oil to satisfy demand, exports of soybean oil did not take off until after 1975 and only when the domestic market had supposedly been supplied.

Rapidly rising petroleum prices severely upset the balance of trade in late 1973. Consequently Brazil reinstated similar pre-1968 trade controls in 1974. The mini-devaluations of the cruzeiro slowed down, so that it gradually overvalued again and imposed an implicit tax on all exports, including soybeans and products. Schuh estimated that overvaluation reached 25 percent *(20)*.

The Government eliminated the retention system in 1974 and began to control soybean and soybean meal exports through export licensing. Soybean oil exports were still banned, and the value-added tax on bean exports dropped to 9.75 percent. Bean and meal exports were temporarily suspended in July 1974 when the Government appraised the internal supply situation. A new export system for beans established that the export volume in any period should not exceed the exportable surplus, defined as total production less installed crushing capacity. Meal exports resumed when the crushing industry agreed to assure an adequate supply of meal for the domestic market. The mixed feed industry protested that crushers underestimated needs, which forced suspension of meal exports again in November 1974. Small quantities of oil exports resumed in December 1974.

The growth in volume of soybeans crushed and the export restrictions triggered both meal- and oil-stock increases in 1975. Export controls were removed and the value-added tax on bean exports again was raised to 12.5 percent, slightly below the domestic sales tax rate of 13 to 14 percent depending on the state. (Because the tax on soybean exports is charged on the f.o.b. export price less port and transportation costs, the effective domestic rate may have been only about 11.6 percent.) Domestic sales of soybean meal were not taxed because "modern agricultural inputs" were exempt. Although a 5-percent tax was charged on meal exports in 1975, the incentive still rested on crushing soybeans and exporting the meal.

Soybean oil exports escaped taxation in 1975, but up to 14 percent was charged on domestic sales. Exports also profited from a 16-percent subsidy in the form of a tax credit against the Federal value-added tax on industrial products and the state sales tax. Soybean oil exports also received an exemption on pretax profits from the Federal income tax of 30 percent. In 1976 oil and meal exports benefited from a special export financing scheme, referred to as Resolution No. 674, which allowed exporters to receive financing on a certain percentage of the previous year's exports at subsidized interest rates. But in keeping with general policy, such financing was not available for bean exports.

The basic structure of the bean and meal export policy in 1976 changed little from 1975. When bean exports slowed after harvest, the export tax on them was decreased to 10 percent for April, May, and June, and the Government devalued the cruzeiro four times

within 66 days. Once the rate of bean exports picked up significantly the industry was prohibited from exporting more so as not to exhaust the domestic supply. The oil export tax credit dropped from 16 to 14 percent in January 1976. It was raised back to 20 percent, however, when new-crop soybeans became available. The United States threatened to take retaliatory action under Section 301 if Brazil did not stop subsidizing soybean oil exports by this means. As a result, the credit was reduced to 14 percent again on July 1, 1976, 8 percent on January 1, 1977, and 4 percent on July 1, 1977. The credit disappeared entirely on December 31, 1977. Export sales of crude and refined soybean oil, nevertheless, continued exempt from the 30-percent corporate income tax.

The Government authorized soybean oil and meal exports at the beginning of 1977, after an agreement with the crushers that 1 million tons of oil and 1.2 million tons of meal would be retained for domestic consumption. Export controls were essentially policed by the crushers' association. Exports were authorized once CACEX certified that sufficient meal and oil were available to keep domestic prices below the ceilings imposed by the Price Commission. However, when the 1977 marketing year began and world market prices approached historic highs, the Government imposed an export embargo on March 11. On March 23 the Government imposed an *ad valorem* tax of 7 percent on soybean, meal, and oil exports to hold down domestic prices. The Government also may have intended to exploit the apparent inelastic export demand which existed in a period of low world stocks 6 months before the U.S. crop would be harvested. The export *ad valorem* tax increased to 12 percent on May 3, dropped to 7 percent on July 1, dropped to 4 percent on July 25, and disappeared altogether on August 18, 1977. The mini-devaluations of the cruzeiro also slowed during this period to increase the implicit export taxation. Because the export tax was in effect in 1977, part of the revenue was given to crushers as a specific subsidy for quantities sold on the domestic market.

The Federation of European Community Seed Crushers and Oil Processors (FEDIOL) filed an antidumping complaint with the European Community Commission in 1977 against Brazilian soybean meal *(4)*. They protested an "unfair" tax advantage of exported meal over beans and claimed that the policy encouraged domestic crushing and exports of meal at a time when the European Community had substantially expanded its own capacity. As a result, the Brazilian Government agreed to impose a special 3-percent export tax on meal on November 21, 1977, and raised the total tax on meal exports to 8 percent. Under the agreement, the total tax on meal increased to 9.6 percent on May 1, 1978, and to 11.1 percent on November 1, 1978. The entire export tax was based on value-added, beginning in May 1978. No such tax existed for oil exports, but 13 percent was charged on bean exports. The value-added tax rates did not change again between 1978 and 1982 for beans. The Government placed an 11.78-percent sales tax on interstate trade of oil and 15 percent on intrastate trade. Also, a value-added tax of 8 percent was placed on soybean oil exports. The differential favoring the export of meal and oil over beans narrowed substantially. The export financing scheme, however, continued to encourage exports of meal and oil but not of beans.

Brazilian soybean imports rose dramatically under a duty drawback scheme after the soybean-crop shortfall of 1978. Under this scheme, Brazilian crushers could import soybeans, process them, and export the products free of duties, taxes, and quotas. The Government financed the imports at an interest rate of 4.5 percent per month, well below the market rate of 7 to 8 percent. The products had to be exported within a year of importing the soybeans, but financing was available for a maximum of only 180 days. The program allowed processors to use excess capacity as well as maximum use of Brazilian-produced soybeans for the domestic market rather than for export. Brazilian crushers imported about 474,000 tons of soybeans under this scheme in 1980/81.

The volume of exports of soybeans, meal, and oil continued to be controlled from 1974 to 1981, although the tax system worked to subsidize exports of both soybean meal and oil. The export quota system began each year when CACEX authorized export registrations for specific amounts of beans, meal, and oil. Small quotas were established early in the marketing year, and additional quotas were assigned as the season progressed. When, and if, domestic supplies of one of these products appeared to be threatened, registrations shut down. Export authorizations were divided among states and between cooperatives and private traders. Associations of cooperatives and of traders in each state then redivided the authorizations among their members.

Domestic quotas replaced export quotas for oil and meal in February 1979. Crushers signed agreements with CACEX to guarantee supplies of oil and meal for the domestic market. In return, quotas and other restrictions on exports of these products were withdrawn, although beans were not affected. Only a month later, export registrations for meal and oil were closed because of "excessive export registrations which would leave the domestic market with insufficient supplies." The crushers were accused of not living up to the agreement that had been made. Export registrations reopened on April 23 and 24, 1979, and export quotas were announced for 5 million tons of soymeal and 567,000 tons of oil.

Import restrictions on soybeans and soybean oil were relaxed in mid-1979 to alleviate domestic shortages caused by the drought in 1978 and 1979. The import tax on soybean oil was completely eliminated in October 1979. The cruzeiro was devalued by 30 percent in December 1979. To counter the effect of this devaluation on exports of soybeans and products, a new economic program was announced to establish differential export taxes on these products. The taxes combined with the value-added tax at 20 percent of the f.o.b. value for beans, $250 per ton for crude oil, and $85 per ton for meal. This tax structure still favored oil and meal exports over beans by roughly $25 to $30 per ton.

The special export taxes were changed in January 1980 to 12 percent, 8 percent, and 10 percent of the f.o.b. value of beans, oil, and meal, respectively. A month later, they were readjusted to 13 percent, 5 percent, and 28 percent, respectively, and at the same time, the export quotas on all three products expanded. The sharp increase in the oil tax was to insure adequate domestic supplies. The new tax structure reduced the advantage to export oil and meal over beans to between $5 and $6 per ton, ignoring the value-added taxes that remained unchanged. Overall, soybean oil and meal exports enjoyed a total advantage of about $20 per ton over bean exports.

On March 17, 1980, authorities announced staunch support of their export tax policy in the face of rising domestic protest and reaffirmed their intention to maintain the rates previously announced. This incited producers to threaten to withhold beans from the market and to refrain from planting wheat. After several meetings with Government officials and representatives of industry and exporters, the taxes on soybeans and products were eliminated on April 1, 1980. The next day, however, the Government announced a contingency plan to limit exports for the 1980 season to 6 million tons of meal, 1.5 million tons of beans, and 800,000 tons of oil. Officials claimed the limits would maintain an orderly market, and, at the same time, protect consumers. The Government warned the private sector that it would reinstate export taxes or fix internal market prices if the domestic market got "too far out of line." Export rights were exchanged among crushers during the 1980 season, but this practice was banned the next year. The export policy for 1981 remained relatively unchanged from the previous year except for some more minor changes in sales reporting procedures *(27)*.

The removal of export quotas on soybeans and products came 2 months before the 1982 harvest. Import duties on soybeans and products for domestic use were eliminated. All other trade policies, including the value-added tax and the export financing program, stayed in place. When quotas were lifted, exports of soybean products received an additional advantage from a fixed exchange rate; after a sale, the exchange rate at the time is fixed for soybean products for up to 180 days; the rate for soybeans is set at 30 days or until shipping occurs. This procedure eliminated the potentially large exchange risk on export valuation.

An Analysis of the Market

Econometric procedures that employed seven equations measured the complex relationships in the Brazilian market. Prices, policies, and other factors were examined for their effects on (1) soybean production, (2) soybean crush, (3) domestic demand for edible oils (soybean oil, peanut oil, and cottonseed oil), and (4) domestic demand for high protein meals (soybean meal, peanut meal, and cottonseed meal in soybean meal equivalents). Three equations to measure Brazilian intervention in domestic markets were also included.

The foregoing relationships are part of a complete Brazilian soybean economy model which, in turn, represents one component of a simultaneous, 88-equation world soybean model *(33)*. The world model includes similar components for the United States, the European Community, Japan, Canada, Africa, Other Asia and Oceania, and an aggregate for the rest of the world. The two-stage least squares procedure permitted calculation of the coefficients in the world model.

The period used for estimating coefficients of each economic relation was from 1960 to 1978. A number of analytical statistics support each equation, including the coefficient of multiple determination or R-squared (RSQ), the corrected R-squared (CRSQ)[4], the Durbin-Watson (DW) statistic for auto-correlation[5], the F-statistic (a test of the significance of a multiple regression equation), the standard error of the estimated coefficient of each independent variable (STER), and Student's t-statistic or T-STAT.[6] All prices are in real cruzeiros per ton (that is, divided by an appropriate inflation index), and all quantities are in 1,000 tons.

The results of estimating the coefficients of the seven behavioral equations of the Brazilian component were highly satisfactory.[7] The CRSQ for all but two equations was over 0.9. The signs of the estimated coefficients in each equation were consistent with a *priori* expectations. Serial correlation is not indicated by the Durbin-Watson statistic for any equation. Data used are from *(32)*.

The Supplv of Soybeans Equation

The original specification of equation (1) was based on the linear Nerlovian distributed lag concept *(17)*. However, in validating the Brazilian model, the linear version of equation (1) tended to simulate relatively high values in early years and low values in late years despite a CRSQ of 0.978. The reason for this problem was the high rate of increase in soybean production (SSBBZ) after the late sixties. Consequently, a double log specification was used to better represent the rapid increase in production over the period. Unfortuitously this resulted in lower t-values of the estimated coefficients of the explanatory variables in the equation, although their signs continued to reflect a *priori* expectations. While the CRSQ of the alternate specifications was slightly lower than the linear version (0.97), the simulated values of SSBBZ were much closer to actual values.[8]

Equation (1) Soybean Supply:

LN (SSBBZ) = B10 + B11 * LN (PSBBZ(−1)) + B13 LN (PWTBZL1) + B15 * LN (ACBBZ) + B17 * LN (SSBBZ(−1)) + B18 * DRTBZ

Number of Observations (NOB) = 19
RSQ=0.98136 CRSQ=0.97419
F(5/13)=136.871 DW=2.68
LN (SSBBZ) MEAN=7.28302

COEF	VALUE	STER	T-STAT	VARIABLE MEAN
B10	5.96419	6.32133	0.94350	1.00000
B11	.53377	.52853	1.00992	5.24034
B13	−.98039	.58463	−1.67693	5.38584
B15	−.27167	.42290	−.64240	7.91162
B17	.84530	.14566	5.80355	7.06164
B18	−.34166	.30600	−1.11653	.05263

The higher standard errors of the estimated coefficients in the nonlinear version of equation (1) than in the linear version may be the result of collinearity because a tendency toward high correlation exists among logged variables. The coefficient of the lagged price of soybeans (PSBBZ(−1) is positive, as expected. The expected sign of the coefficient of the lagged price of wheat (PWTBZL1), however, is ambiguous. There are two opposing forces affecting the relationship between wheat and soybeans: (1) the complementary effect of double-cropping of wheat and soybeans and the positive influence of wheat policy on soybean production, and (2) a negative interaction between double-cropping and soybean yields. The results of this study suggest that over the study period the net effect was negative but weaker than reported in previous studies. This is plausible because the area under double-cropped wheat and soybeans has decreased in recent years. Other studies, such as *(9)* and *(10)*, have also revealed a strong, negative relationship between wheat and soybeans.

[4] The RSQ and CRSQ in each case was calculated using the observed values of the variables in the equation and, thus, have a range of minus infinity to 1 *(18)*.

[5] It is important to emphasize that the Durbin-Watson test was derived for nonstochastic independent variables and is not strictly applicable when lagged dependent values appear among explanatory variables *(13)*. However, Taylor and Wilson *(23)* provide extensive evidence on the power of the Durbin-Watson test in inappropriate situations. They conclude that the test is "quite powerful" in detecting serial correlations in inappropriate situations.

[6] The t-ratio is defined here as the value of the estimated coefficient of a variable divided by its standard error. If the estimated coefficient is at least twice the size of its standard error, the t-ratio is termed "high," otherwise it is termed "low." It is used in this study to compare the various estimated coefficients while avoiding the statistical rigor implied by the use of Student's t-statistic. For 2-stage least squares (2SLS), the t-statistic holds only asymptotically. Its small sample properties are not well known.

[7] The principal components method (referred to as INST in the tables which follow) was used to calculate a set of 16 components from the set of exogenous variables in the complete model in the first stage of the ZSLS procedure. Note that for each equation with right-hand-side (RHS) endogenous variables, a small table that lists the coefficients estimated for the RHS endogenous variables calculated in the first stage by the principal components (INST) method accompanies the statistical data for those equations.

[8] The validation results are discussed later in this section.

The relatively high standard error of the estimated coefficient of coffee acreage (ACBBZ) suggests that soybeans and coffee were only marginal competitors for area on average over time. In certain years, soybeans were substituted for coffee, but the results fail to support the hypothesis that there was an overwhelming trend in that direction.

In the original specification of the soybean production equation, the lagged deflated producer price of corn (PCPBZL1) was also included. A high standard error of its estimated coefficient, however, led to the deletion of PCPBZL1 from the equation. This result is not surprising because it was expected that the competitive relationship observed between corn and soybeans in many areas of Brazil had been largely offset by the practice of interplanting corn and soybeans on small farms.

The lagged production variable (SSBBZ(-1)) reflects a partial adjustment effect because of the rigidities in the crop production process *(17)*. Finally a dummy variable representing a drought that substantially lowered soybean yields in 1978 (DRTBZ) was included in the final specification.

The Demand for Crushing Equation

Changes in crushing capacity (CAPBZ) and in the availability of soybeans for crushing, as measured by movements in the production of soybeans (SSBBZ), dominated other factors in determining the volume of soybeans crushed (CSBBZ) over the sample period in equation (2). This is indicated by the extremely high t-ratios on the estimated coefficients of CAPBZ and SSBBZ. The deflated profit margins of cottonseed (MCSBZ), peanuts (MPNBZ), and soybeans (MSBBZ) were also included in its original specification. While both MCSBZ and MPNBZ had the expected negative values, they both had extremely low t-ratios and were consequently dropped from the equation. MSBBZ had the expected positive sign but also had a low t-ratio. It was decided to leave MSBBZ in the equation, however, because it provides an important economic link between the soybean and the soybean derivatives sector of the economy.

Equation (2) Soybean Crush:

CSBBZ = B20 + B21 * MSBBZ + B23 * SSBBZ + B24 * CAPBZ

NOB = 19
RSQ = 0.99772 CRSQ = 0.99727
F(3/15) = 2189.120 DW = 2.05
CSBBZ MEAN = 2363.37000

COEF	VALUE	STER	T-STAT	VARIABLE MEAN
B20	−49.83310	111.91100	−0.44529	1.00000
B21	.23507	.44836	.52427	181.38900
B23	.22837	.02809	8.13070	3569.47000
B24	.51292	.03012	17.02900	3032.43000

COEF	METHOD	PARAMETERS
B21	INST	ENDOGENOUS
B23	INST	ENDOGENOUS

As discussed in the previous section, the growth in new crushing capacity was exceeded by the growth in soybean production in all but the last few years of the sample period. Thus, the availability of soybeans for crushing increased rapidly and furnished a large positive influence on soybean crush; the available crush capacity acted as a constraint on the level of soybean crush. When the level of crush capacity exceeded the level of soybean output each year during the late seventies, the volume of soybeans crushed annually was constrained largely by the available supply. Throughout this period, the soybean crushing margin remained high enough that movements in the margin appeared to have little influence on the volume of soybeans crushed. Indeed, the elasticity of crush with respect to the deflated margin is about 0.01 when computed at the means of the data.[9]

The Brazilian Demand for Oils Equation

Multicollinearity among prices for individual oils has invariably caused serious problems for econometricians *(14)*. Oils were consequently grouped according to their physical characteristics and uses.[10] The consumption data for soybean oil, peanut oil, and cottonseed oil were aggregated and a demand for edible oils (DOLBZ) equation was estimated rather than individual oil demand equations.[11] The edible oil group price

[9] The reader should be aware that the concept of the partial derivative with all else constant is not strictly valid in a simultaneous system. Therefore, references to "elasticity" are used sparingly in this report and must be interpreted somewhat loosely.

[10] The groupings were based on information in *(30)*.

[11] In the complete world soybean economy model, several fats and oils groups were identified including: oleic-linoleic/linolenic acid oils (soybean oil, cottonseed oil, peanut oil), lauric acid oils (coconut oil and palm kernel oil), industrial oils (tung oil, castor oil, and linseed oil), palm oil, animal fats (butter, tallow, and lard), and fish oils (menhaden oil). Rapeseed oil, the only commercially important erucic acid oil, was grouped where appropriate with oleic-linoleic/linolenic acid oils because of their similar uses. In this soybean model, the oleic-linoleic/linolenic oil groups are endogenous, and the other oil groups remain exogenous and interact with that group through their aggregate price variables.

(POLBZ) is a weighted average of the prices of the oils in the group. The weights are the proportion of the total demand accounted for by the individual oils in the group.

The vegetable oil sector is affected by the large number of policy controls maintained by the Government, chiefly the quota maintained on exports of soybean oil which held down prices of vegetable oil. The volume of soybean oil consumed is treated as the difference between the production of soybean oil (SSOBZ), which is determined by the soybean crush, and soybean oil exports (QSOBZ), which are determined by policymakers. Fluctuations in the real price of soybean oil consequently have been largely determined by changes in the quantity "available" to the domestic market. Because soybean oil has dominated the Brazilian oils market since the early seventies, the aggregate real price of oils (POLBZ in equation (3)) was specified as a function of the aggregate demand for oils (DOLBZ). The sign on the estimated coefficient of DOLBZ is negative, as expected, with a high t-ratio.

Equation (3) Vegetable Oil Demand:

POLBZ = B30 + B31 * DOLBZ + B32 * PLDBZ + B33 * PBTBZ + P34 * QSOBZ

NOB=19
RSQ=0.8778 CRSQ=0.84289
F(4/14)=25.142 DW=1.47
POLBZ MEAN=1079.23

COEF	VALUE	STER	T-STAT	VARIABLE MEAN
B30	465.42500	292.05200	1.59364	1.00000
B31	−.83308	.20445	−4.07483	588.78900
B32	.31359	.11694	2.68175	1349.18000
B33	.19039	.09408	2.02373	3208.56000
B34	.68693	.28813	2.38411	102.42100

COEF	METHOD	PARAMETERS
B31	INST	ENDOGENOUS
B34	INST	ENDOGENOUS

Also included in equation (3) were the real prices of lard (PLDBZ) and butter (PBTBZ) and a policy variable (QSOBZ) which measured the positive influence of the export quota on the level of POLBZ. The higher the soybean oil export quota in each year, the lower the domestic availability of oils and, consequently, the higher the domestic price of oils. The signs on both PLDBZ and PBTBZ are positive, as expected, with high t-ratios, indicating the strong competitive relationships among vegetable oils and the more traditionally used animal fats (largely for cooking purposes). The soybean oil quota (QSOBZ) also exerted an important influence on the level of vegetable oil prices according to equation (3). As expected, the higher the soybean oil quota was set over the period, the higher the internal real price of oils. Although the CRSQ was somewhat low (0.84), the equation performed satisfactorily in validation.

The Demand for High-Protein Meal Equation

The data for the disappearance of high-protein meals were aggregated into a single variable (DHPBZ) for the same reasons that the oils disappearance data were aggregated into a single variable. Included in the demand variable for high-protein meals in equation (4) were soybean meal, cottonseed meal, and peanut meal.[12] Because the digestible protein content differs for each meal, data were adjusted to a soybean meal protein equivalent basis before aggregation.

Equation (4) Demand For High-Protein Meal:

DHPBZ = B40 − 0.872447 * PHPBZ + B46 * INCBZ

NOB=19
RSQ=0.89037 CRSQ=0.88392
F(1/17)=138.062 DW=1.57
DHPBZ MEAN=834.47400

COEF	VALUE	STER	T-STAT	VARIABLE MEAN
B40	393.29900	57.48950	6.84123	1.00000
B46	7.57605	.63589	11.91410	80.26210

The modernization and rapid growth of the poultry industry was the major force behind the increasing demand for high-protein supplements by the mixed feed

[12] In the complete world soybean economy models, two meal groups were identified: high-protein meals (soybean meal, cottonseed meal, peanut meal, and where appropriate, rapeseed meal) and low-protein meals (copra meal and palm kernel meal). In the world soybean model, the high-protein meal equations are endogenous while the low-protein meal group remains exogenous. The low-protein meal group interacts with the high-protein meal group through its aggregate price variable, where appropriate.

industry. Because the available data on flock and herd size are highly questionable *(29)*, real disposable income (INCBZ) was used in equation (4) to account for the influence of the rapid growth of poultry and livestock industries on the demand for high-protein meals. Income changes affect the demand for meat which determines the number of the poultry, hogs, and cattle on farms. Because poultry flocks adjust quickly to changes in demand, income changes can be assumed contemporaneously to affect poultry numbers, and thus, the shortrun demand for high-protein meals. As expected, the sign on the coefficient of INCBZ was positive with a high t-ratio. Repeated attempts to obtain a negative sign for the aggregate deflated price of high-protein meals (PHPBZ) were unsuccessful. Consequently, PHPBZ was forced into equation (4) with an elasticity of about -0.2 which is consistent with the elasticities for the high-protein price variable in the high-protein demand equations of the other regions in the complete world model. The CRSQ was 0.88, and the equation performed well in simulation.

The Policy Intervention Equations

When Brazilian policymakers deem world prices to be politically unacceptable, they intervene to raise or reduce the prices received by procedures and/or paid by consumers. The level of intervention is defined as the difference between the f.o.b. export price and the domestic price to producers or users as the case may be.[13]

The level of intervention for a given product is generally the net effect of policies designed to meet a number of objectives. These typically include an objective of holding down consumer prices, supporting producer prices, increasing Government revenues, and altering the distribution of income among sectors of the economy. Most researchers assume that Government intervention in a given commodity market is determined exogenously to the analytical model used, in part because the policies designed to meet the objectives of intervention are often complex and diverse. However, a number of researchers, including Lattimore and Schuh *(15)*, Thompson and Schuh *(26)*, Griffith *(11)*, and Gulliver *(12)*, have demonstrated that variations in the level of Government intervention can be explained largely by a limited set of economic and policy variables, which include the price of the commodity, the general rate of price inflation, the balance of payments, and other indicators (both endogenous and exogenous) of policymakers' behavior in determining the level of intervention. In this way, the response of policymakers to changes in economic conditions becomes endogenous to the model. Thus, in using the model for analytical purposes, one should recognize that Government behavior in commodity markets not only affects but also responds to changes in the endogenous variables which leads to more plausible results.

Policies Related to Beans. The soybean market intervention equation (5) reflects the Brazilian policymakers' objective of holding down the cost of soybeans to domestic crushers to encourage the domestic crush of soybeans and the production of soybean derivatives. An indicator of Brazilian policymakers' interest in holding down the price of soybeans is provided by the rate of inflation, as measured by the general price index (GPIBZ). Other things being equal, an increase in the rate of inflation over the period led to a greater level of intervention (defined as the difference between the f.o.b. export price of soybeans (PSBXBZ) and the Brazilian producer price of soybeans (PSBBZ)) when policymakers attempted to hold down the cost of soybeans to the crusher. The world price of soybeans (PSBXBZ) was also included as an explanatory variable since the greater the world price of soybeans the greater the level of intervention necessary to maintain a given price in the Brazilian market. The CRSQ for this equation was 0.95.

Equation (5) Soybean Policy:

PSBXBZ − PSBBZ = B50 + B51 * PSBXBZ + B53 * GPIBZ

NOB = 19
RSQ = 0.95258 CRSQ = 0.94665
F(2/16) = 160.710 DW = 1.68
PSBXBZ − PSBBZ MEAN = 54.37680

COEF	VALUE	STER	T-STAT	VARIABLE MEAN
B50	−116.2660	11.91980	−9.75397	1.00000
B51	.63774	.05194	12.27890	243.63200
B53	4.22683	.78975	5.35214	3.61255

COEF	METHOD	PARAMETERS
B51	INST	ENDOGENOUS

[13] In this study, the official rate of exchange was used to convert the f.o.b. export price to Brazilian cruzeiros. Because the market exchange rate has been distorted by Government policy, a free trade or equilibrium exchange rate, if available, could be used to better measure the actual level of intervention.

Policies Related to Meal. The two conflicting primary reasons behind the intervention in the soybean meal market over the period were the policymakers' desire to hold down the internal rate of inflation, and their desire to encourage domestic crushing rather than exports of soybeans.[14] As in the preceding equation, the general price index (GPIBZ) was also used here as an indicator of the pressure on policymakers to hold down prices. In this case, however, the pressure comes from livestock producers and from consumers of meat and poultry products rather than from crushers. When policymakers react to consumer pressure to hold down meat and poultry prices, producers pressure policymakers to hold down growers' production, which revolve around soybean meal.

Equation (6) Soybean Meal Policy:

PSMBZ − PSMXBZ = B60 + B61 * PSMXBZ + B62 * BOPBZ(−1) + B63 * GPIBZ(−1) + B64 * INCBZ + B65 * DN1BZ + B66 * DN2BZ

NOB = 19
RSQ = 0.93587 CRSQ = 0.90381
F(6/12) = 29.189 DW = 2.09
PSMBZ − PSMXBZ MEAN = 7.81159

COEF	VALUE	STER	T-STAT	VARIABLE MEAN
B60	58.96350	72.75540	0.81043	1.00000
B61	−1.04185	.11866	−8.78021	199.86300
B62	.00617	.00567	1.08859	388.10500
B63	−10.10350	4.90633	−2.05928	2.71325
B64	1.60230	.81371	1.96912	80.26210
B65	78.82260	52.25780	1.50834	.47368
B66	61.37480	33.60310	1.82646	.26316

COEF	METHOD	PARAMETERS
B61	INST	ENDOGENOUS

Because the impact of changes in the wholesale price of soybean meal on the retail price of meat and poultry may not show up fully in one period, consumer pressure on policymakers to hold down the retail price of meat, and livestock producer pressure to hold down the price of soybean meal may lag behind actual increases in the domestic price of soybean meal. The general price index, therefore, is lagged one period in equation (6). The estimated coefficient of GPIBZ(-1) was negative, as expected, with a high t-ratio. Along with GPIBZ(-1), the f.o.b. export price of soybean meal (PSMXBZ) had an expected negative sign because the lower the world price of soybean meal, the greater the level of intervention necessary to maintain a given internal price of soybean meal.

Policymaker interest in crushing rather than exporting soybeans is measured by the impact of changes in the balance of payments in the previous period (BOPBZ(-1)) on the level of intervention in the soybean meal market. It is assumed that when the expected balance of payments is in surplus (or the expected surplus rises), the Government tends to increase the level of intervention, other things being equal, because the country can afford to increase soybean meal prices to encourage domestic crushing of soybeans and sacrifice export earnings without precipitating a balance of payments problem. On the other hand, if the Government expects a deficit in the overall balance of payments (or if the deficit is expected to rise), it will tend to reduce the level of intervention in order to help ameliorate the foreign exchange problem. Although the coefficient of BOPBZ(-1) has the expected positive sign, it is less than twice the size of its standard error.

Also included in equation (6) are the real disposable income (INCBZ), and two binary policy variables (DN1BZ and DN2BZ). INCBZ captures the positive influence on intervention from increasing demand for meat and poultry (and thereby for soybean meal) over the period. The estimated coefficient of INCBZ is positive as expected with a t-ratio of two. The two binary variables capture the impact on the level of Government intervention from a sharp turn in the Government's policy from 1960-69 to 1969-74. The 1969-74 period saw an unusual surge of economic liberalism when A. Delfim Netto was the Brazilian Minister of Finance. Government intervention in all sectors of the economy abated considerably *(10, 15, 26)*.

Policies Related to Oil. The soybean oil export quotas are reflected in equation (7). In determining the soybean oil quota level in each year, policymakers were

[14] The reader should note that since the domestic price of soymeal (PSMBZ) exceeded the Brazilian export price of soymeal (PSMXBZ) on average over the period, "intervention" is defined as the internal price minus the export price rather than the reverse as was the case for soybeans. As a result, the expected signs on similar variables in equations (5) and (6) are exactly opposite.

greatly influenced by: (1) their desire to insure adequate supplies of vegetable oil to the domestic market and to hold down the politically sensitive internal price of vegetable oils, and (2) pressure from crushers and refiners to allow internal soybean oil prices received to increase to help offset rising costs of production. Policymakers tend to watch the level of soybean production as an indication of the adequacy of soybean oil supplies in the market. When production falls, export quota levels are reduced to maintain supplies and hold down prices. When production increases, soybean oil tends to be exported after it is determined that domestic needs have been met. The estimated coefficient of the production of soybeans (SSBBZ) in equation (7) is positive, as expected, with a high t-ratio.

Equation (7) Soybean Oil Policy:

QSOBZ = B70 + B72 * SSBBZ + B73 * BOPBZ(−1) + B74 * GPIBZ + B75 * DN1BZ + B76 * DN2BZ

NOB=19
RSQ=0.96403 CRSQ=0.95019
F(5/13)=69.676 DW=1.62
QSOBZ MEAN=102.42100

COEF	VALUE	STER	T-STAT	VARIABLE MEAN
B70	−349.92600	98.05250	−3.56876	1.00000
B72	.04781	.01080	4.42800	3569.47000
B73	−.03374	.01149	−2.93553	388.10500
B74	26.52770	4.91527	5.39700	3.61255
B75	305.92300	95.02210	3.21949	.47368
B76	205.34200	78.69350	2.60938	.26316

COEF	METHOD	PARAMETERS
B72	INST	ENDOGENOUS

When the balance of payments is expected to be in surplus, or the surplus is expected to increase (as indicated by BOPBZ(-1)), the Government tends to reduce export quotas because the country can afford to increase domestic supplies, drop prices, and sacrifice export earnings without a balance of payments problem. If the balance of payments is in deficit or is expected to fall, the Government tends to increase export quotas to help overcome an expected shortage of foreign exchange.

Movements in GPIBZ over the period also tended to influence policymaker decisions regarding soybean oil export quotas. Because of the soybean oil consumption tax and price ceiling administered by the Government, soybean oil prices were allowed to move up with inflation over the period. Otherwise the resulting cost squeeze on crushers and refiners would have severely reduced the domestic supply of soybean oil. By increasing the soybean oil quota as the rate of inflation increased, the Government could allow soybean oil prices received by producers to increase while not sacrificing the tax revenue that a decrease in the tax rate would have meant. The generalized price index (GPIBZ) had a positive sign, as expected, and a high t-ratio. Finally, the equation also included the two policy binary variables (DN1BZ and DN2BZ) to account for the different policy stances between 1960-68 and 1969-73. Both variables had high t-ratios indicating the importance of the policy shift which determined Brazilian soybean oil exports during those periods.

Validation of the Model

An established set of criteria used to evaluate a model concerns the fit of the individual endogenous variables in a simulation context. Because it is expected that the results of a simulation over the historical sample period will match the behavior of the real world rather closely, an evaluation of the model is most often conducted by comparing the simulation results with observed data. The validation results for Brazil were highly satisfactory (table 11).[15]

Effects of Market Intervention

When Brazil entered the world soybean market, U.S. soybean industry and Government officials became concerned over the complex domestic and export policy environment of Brazilian soybeans. These policy actions are removed from the world soybean model in each year (1960-78), and the simulation results are obtained. This process shows the scope and directions of changes in production, consumption, and prices in the world soybean market as a result of Brazilian policies. These results are compared with the base solution values of the world model which represent actual con-

[15] These statistics were obtained to validate the complete world soybean model *(33)*. The statistics for the endogenous variables in the rest of the world soybean model can be found in *(31)*. In fact, the validation statistics were highly satisfactory for the entire world soybean model.

Table 11—Model validation results, 1960–78[1]

Variable name	Mnemonic	Mean error	Mean percent error	RMS percent error[2]	SD percent error[3]	Theil U_2 coefficient
Soybean crush	CSBBZ	−61.85	4.12	16.70	16.63	0.06
High-protein meal demand	DHPBZ	74.54	9.54	19.05	16.94	.16
Edible oils demand	DOLBZ	11.32	2.17	14.58	14.81	.10
Excess supply of soybeans	ESSBBZ	−684.84	−49.21	[4]	67.27	.61
Excess supply of soymeal	ESSMBZ	−81.78	−5.88	[4]	10.90	.09
Crushing margin	MSBBZ	−23.91	24.18	142.13	143.89	.50
High-protein meal price:	PHPBZ	−.27	−.05	2.70	2.77	.03
Edible oils price	POLBZ	−11.57	−.88	5.40	5.48	.05
Soybean price (internal)	PSBBZ	1.80	1.52	9.73	9.88	.09
Soybean price (export)	PSBXBZ	4.96	2.15	15.36	15.63	.14
Soymeal price (internal)	PSMBZ	−.20	.46	7.65	7.85	.07
Soymeal price (export)	PSMXBZ	4.75	2.51	16.73	17.00	.15
Soyoil price (internal)	PSOBZ	−6.52	−.31	20.81	21.39	.21
Soyoil export quota	QSOBZ	−16.52	−16.13	[4]	22.36	.21
Soybean production	SSBBZ	−246.17	2.79	18.40	18.69	.11
Soymeal production	SSMBZ	−46.39	4.12	16.70	16.63	.06
Soyoil production	SSOBZ	−11.44	4.12	16.70	16.63	.06

[1] The formulas used to calculate the statistics in this table can be found in *(16, 18,* and *31).*
[2] RMS = root mean square.
[3] SD = standard deviation.
[4] The calculated RMS percent error is not meaningful because actual or simulation values contain negative numbers.

ditions in world soybean markets given the Brazilian policy.[16]

When intervening in the internal soybean, soybean meal, and soybean oil markets, the Government intends to assure adequate supplies of soybean meal and soybean oil to the domestic market, stimulate expansion of domestic soybean crushing capacity, and export soybean meal and oil instead of raw soybeans up to a level beyond which additional exports would increase domestic soybean meal and oil prices. The set of policies employed appear in the model as the three policy intervention equations discussed earlier and account for changes in policy over time.

The soybean market intervention equation reflects the Brazilian Government's interest in holding down the price of soybeans to stimulate domestic crushing rather than the export of soybeans but not so low as to render soybean production unprofitable. The soybean meal market intervention equation reflects the Government's interest in providing adequate supplies of soybean meal to the feed industry and discouraging exports of beans in favor of meal. Finally the soybean oil export quota equation represents the Government's interest in assuring adequate supplies of soybean oil to the domestic market by prohibiting soybean oil exports when politically expedient. The shortage of oil in Brazil in the sixties relative to demand coupled with

[16] It should be emphasized that in *validation* a set of initial or base solution values are compared against actual data. In *simulation*, the results are compared with the base solution values.

domestic tax policies, forced internal prices of soybean oil in Brazil much above world price levels. Brazil became then a net importer of soybean oil. When domestic soybean oil supplies began to increase, exports were prohibited, and the internal price of soybean oil began to fall in real terms, although domestic sales taxes tended to support its price above world levels.

To measure the effect of Brazilian policies, the three policy intervention equations were removed from the world model and the world prices of soybeans, soybean meal, and soybean oil were linked directly to the internal Brazilian prices of each. The simulation results essentially respond to the inquiry, "What would Brazilian and world levels of production, crush, trade, and prices of soybeans and the production, use, and prices of soybean meal and oil likely have been if the Government had not intervened in its domestic soybean and soybean derivatives markets?"

Brazilian policies, it is believed, have resulted in larger meal and oil exports and smaller exports of soybeans than otherwise would have been the case, a clear intention of Brazilian policymakers. Many also suspect that the increase in Brazilian exports of meal and oil is, to some degree, at the expense of U.S. exports and possibly higher world prices. The domestic prices of both meal and oil for crushers have been supported above world prices, but the soybean price has been held below world levels. Brazilian control of its markets has consequently tended to raise the profitability and thus the level of soybean crush from domestic production and to reduce the export availability of soybeans, and has raised the production and the export availability of soybean meal and oil. A logical conclusion is that the policies have produced a larger Brazilian crush of soybeans, greater domestic and export availability of meal and oil, and lower bean exports. However, this reasoning considers only the shortrun effects of the policies and ignores the dynamic, or longrun, supply response of Brazilian farmers to the low-priced soybeans.

Brazilian intervention in the soybean market has probably caused a lower supply of soybeans than might otherwise have been the case. The lower domestic availability of beans, in turn, meant a smaller crush and smaller exports of meal and oil than occurred over the period. Because the smaller soybean production resulted in a less-than-equal decrease in the crush of soybeans, the export availability of soybeans was also likely affected adversely.

If these adverse effects over time offset the stimulative shortrun effects, then the net impact of the Brazilian policies will have been largely the opposite of what was intended: lower domestic soybean crush and domestic supplies, disappearance, and export availabilities of both meal and oil. For the United States, exports of all three products would have been higher. The question is, then, did the shortrun effects outweigh the longrun effects over time?

The Brazilian intervention policies forced a wedge between the world market and Brazilian price level.[17] The absence of the policies would have likely produced higher bean prices but lower meal and oil prices in Brazil. In the United States and in importing countries, the tendency would have been the opposite, lower bean prices and higher meal and oil prices.
Brazilian soybean production during the sixties was so small that Brazil exerted little influence on world soybean markets. At that time, prices in Brazil were fairly close to world prices. During that early period, the restrictive shortrun effects of the Brazilian policy set likely dominated the longer run effects, leading to an increase in domestic and export availability of both soybeans and soybean products. Because Brazil wielded no market power during this early period, the impact of the policy set on world prices and trade was minimal.

The level of Government intervention in the Brazilian soybean market increased markedly in the seventies, but production and exports rose sufficiently to exert some influence on world price and trade determination. Brazilian intervention in those years led to significantly reduced production and export availability of soybeans. And, because the crush demand for soybeans is highly inelastic regarding changes in the crushing profit margin, the longrun effect of a smaller soybean production likely offset the stimulative, shortrun effects of the higher profit margin on the domestic supply, disappearance, and export availability of soybean meal and oil. The likely effects in the United States during the seventies were just the opposite, that is, reduced soybean production and export availability

[17] For a graphical discussion of this and other general effects of domestic and trade policies on world market conditions in a two-country, one-commodity, partial equilibrium framework, see (*25*).

and reduced domestic supply and export availability of soybean meal and oil.

Simulating the removal of the Brazilian policy set produces different quantities, and prices in each region in the world model, and these movements, in turn, produce simultaneous shortrun and longrun feedback effects through the world market, influencing world prices and trade in each period. Thus, if the Brazilian policies had been terminated, the immediate effect would have been to increase the volume of Brazil's trade in beans, putting downward pressure on world bean prices. In the second year, the lower prices would have reduced soybean production in the world. This feedback would continue from year to year, alternately placing upward and downward pressure on global soybean prices. At the same time, terminating Brazilian policy actions would affect Brazilian exports and world prices of soybean products. Whether these exports and prices increase or decrease, however, depends on the relative Brazilian policy effects of the restrictions on soybean production and the stimuli on soybean product output and exports.

The crush demand for soybeans is much less responsive to changes in the profit margin than demands for oil and meal to changes in their prices in importing countries. Assuming that the long-term supply responses of the United States and Brazil to the termination of Brazilian policy actions would not totally offset the basic shortrun tendencies in price movements in each period as a result of the policy removal, one could expect that world trade in soybeans would increase by a smaller percentage than world trade in meal and oil would decrease.

All variables exhibited movements during the simulation of the Brazilian policy removal consistent with *a priori* expectations. Both the production and export of soybeans from Brazil were dramatically above the base solution values, particularly in the seventies (figs. 1 and 2). In 1977 they were 66 percent and 276 percent higher than their respective base solution values. In 1978 the percentages jumped to 79 percent and 867 percent, respectively, although the 1978 percentage for soybean exports was calculated from a low base value as a result of a drought in Brazil in that year. The production and export of U.S. soybeans dropped an average 28 percent and 32 percent, respectively, during the seventies. World soybean trade, however, increased by 2 to 3 percent over the period.

In the sixties, the policy removal generated somewhat larger Brazilian exports of soybeans and lower exports of soybean meal and oil (figs. 3 and 4). The resulting price adjustments also led to a lower soybean crush. Little longrun supply response existed during the sixties. However, the growth in soybean production in the seventies dominated the shortrun effects, thus generating larger, rather than smaller, exports of soybean meal and oil from Brazil along with even larger exports of soybeans.

The longrun supply response in the United States also dominated the shortrun effects of the Brazilian policy removal during the seventies. This reduced the U.S. crush of soybeans as well as the domestic and excess supplies of soybean meal and oil from the United States. In 1978, for example, U.S. exports of meal and oil were 27 percent and 77 percent below, and Brazilian soybean meal and oil exports were 25 percent and 52 percent above, their respective base solution values (figs. 3 and 4).

World imports of soybean meal dropped 2 to 3 percent over the period because of higher prices, but oil imports dropped by a larger amount, about 13 percent in 1978 alone, despite a 48-percent increase in EC exports of soybean oil that same year.

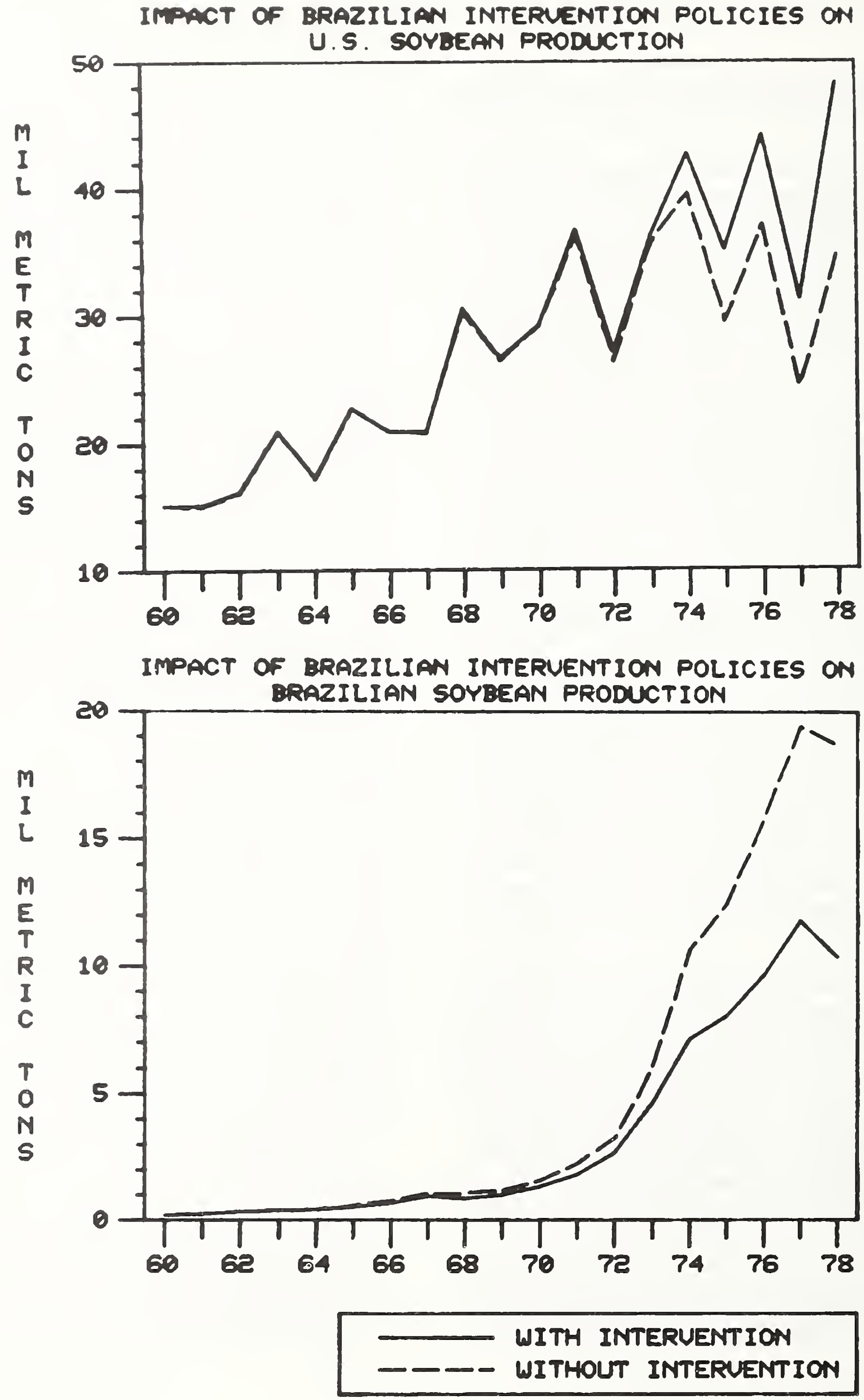
Conclusions

Brazilian interventions in its soybean, oil, and meal markets in the sixties appeared successful in achieving their objectives, that is, a larger domestic soybean crush, lower soybean exports, and larger domestic supplies, disappearance, and exports (or lower imports) of soybean meal and oil. However, intervention during the seventies restricted the growth of soybean production, offsetting the stimulative effects of the intervention in the soybean meal and oil markets and preventing the attainment of the very objectives for which the intervention was undertaken.

Other major conclusions which can be drawn from the simulation results are the following:

- Brazilian policy had very little impact on the world soybean, meal, and oil market before about 1970;
- During the seventies, Brazilian intervention in its soybean and soybean derivatives markets resulted in significantly larger U.S. production and exports of soybeans and larger U.S. production, domestic disappearance, and exports of meal and oil;

Figure 1


IMPACT OF BRAZILIAN INTERVENTION POLICIES ON U.S. SOYBEAN PRODUCTION
MIL METRIC TONS
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68
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74
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78
IMPACT OF BRAZILIAN INTERVENTION POLICIES ON BRAZILIAN SOYBEAN PRODUCTION
MIL METRIC TONS
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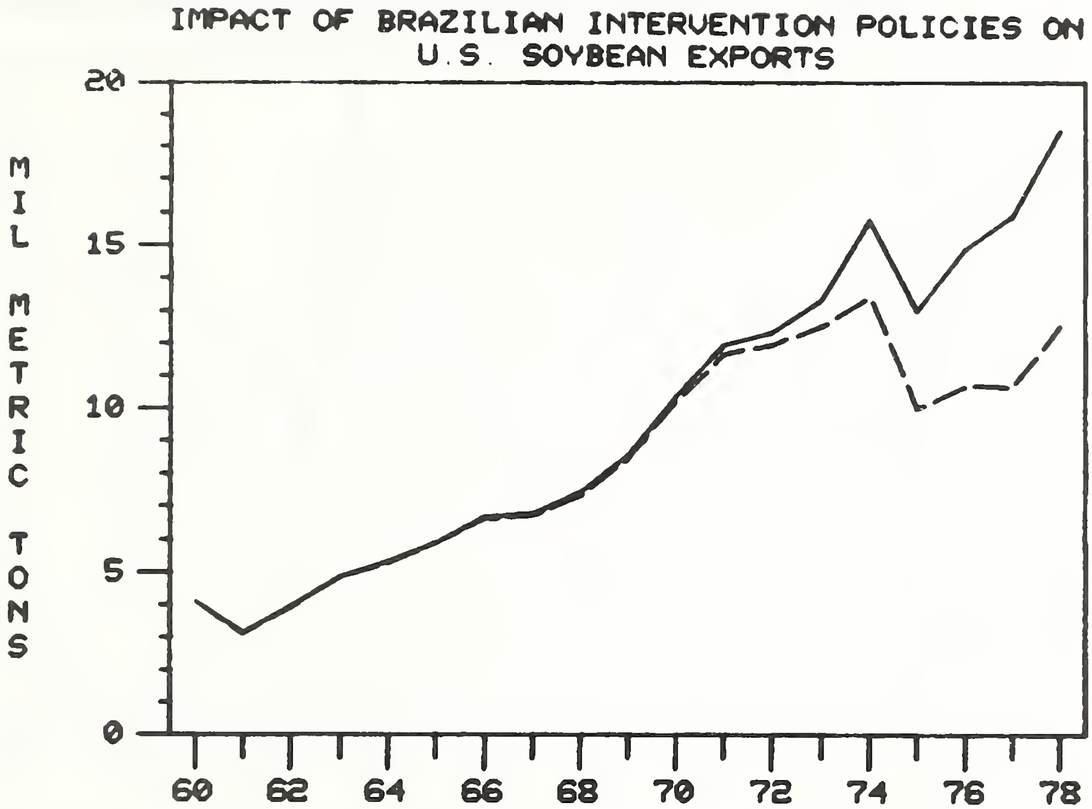
WITH INTERVENTION
WITHOUT INTERVENTION

Figure 2


IMPACT OF BRAZILIAN INTERVENTION POLICIES ON U.S. SOYBEAN EXPORTS
MIL METRIC TONS
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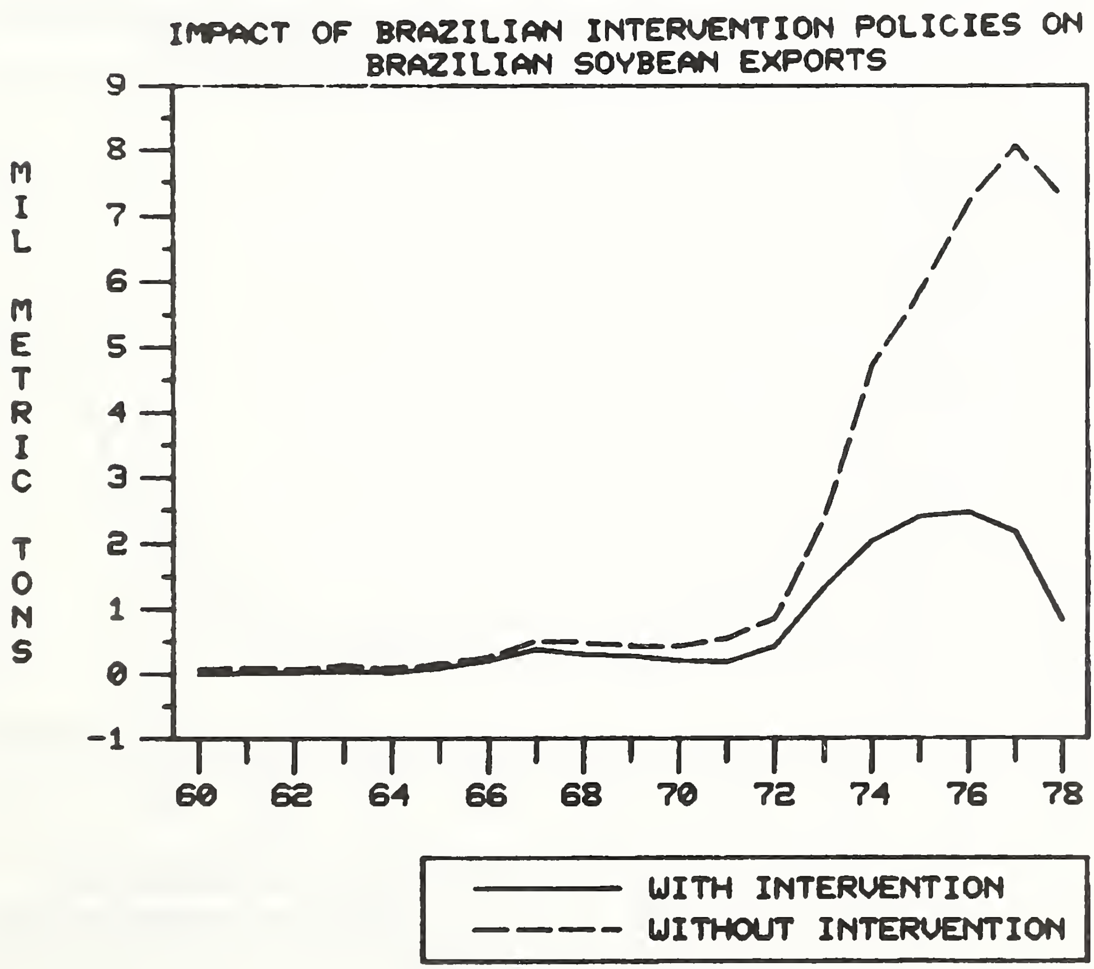
IMPACT OF BRAZILIAN INTERVENTION POLICIES ON BRAZILIAN SOYBEAN EXPORTS
MIL METRIC TONS
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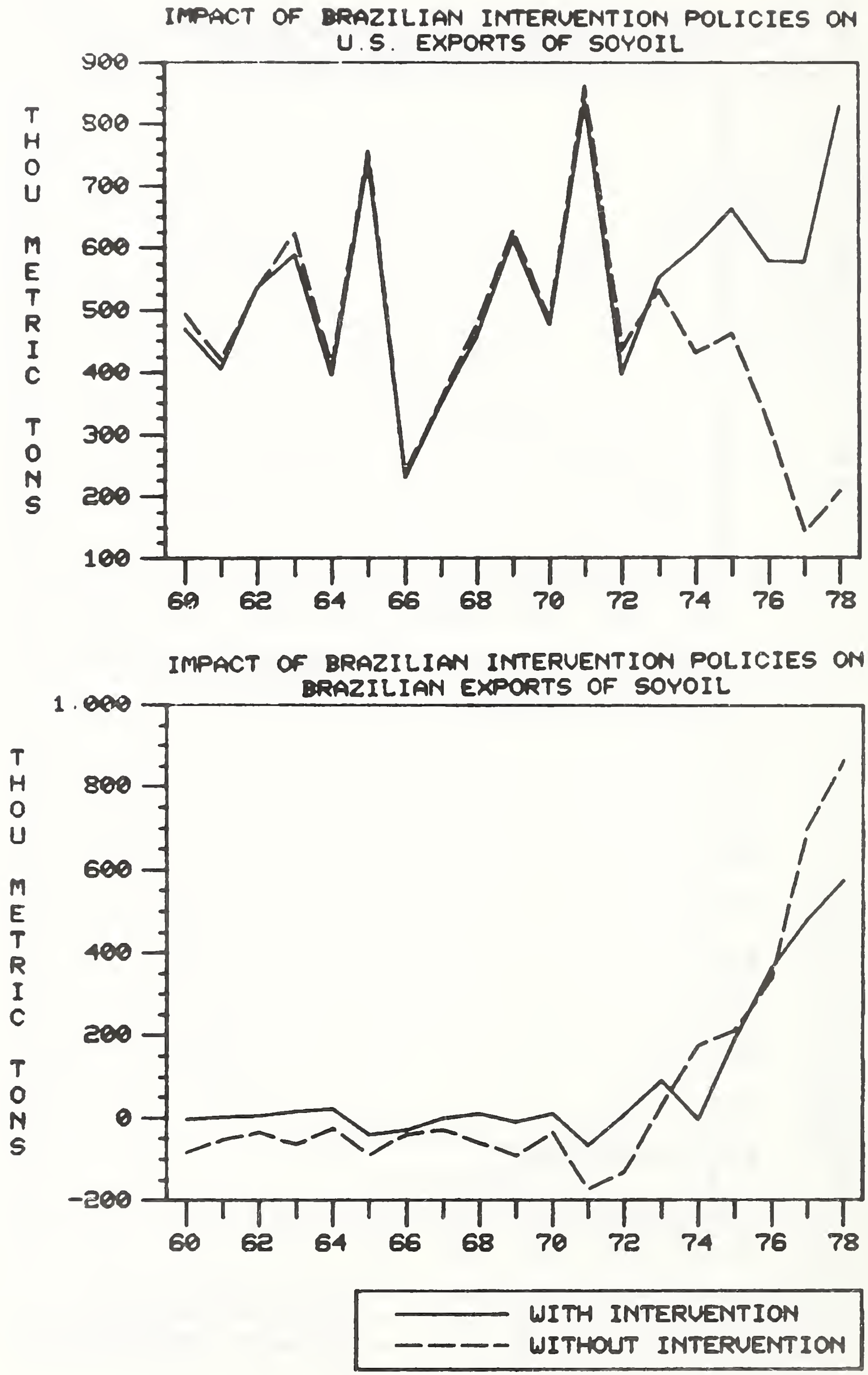
WITH INTERVENTION
WITHOUT INTERVENTION

Figure 3


IMPACT OF BRAZILIAN INTERVENTION POLICIES ON
U.S. EXPORTS OF SOYOIL
THOU METRIC TONS
900
800
700
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500
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200
100
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74
76
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IMPACT OF BRAZILIAN INTERVENTION POLICIES ON
BRAZILIAN EXPORTS OF SOYOIL
THOU METRIC TONS
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800
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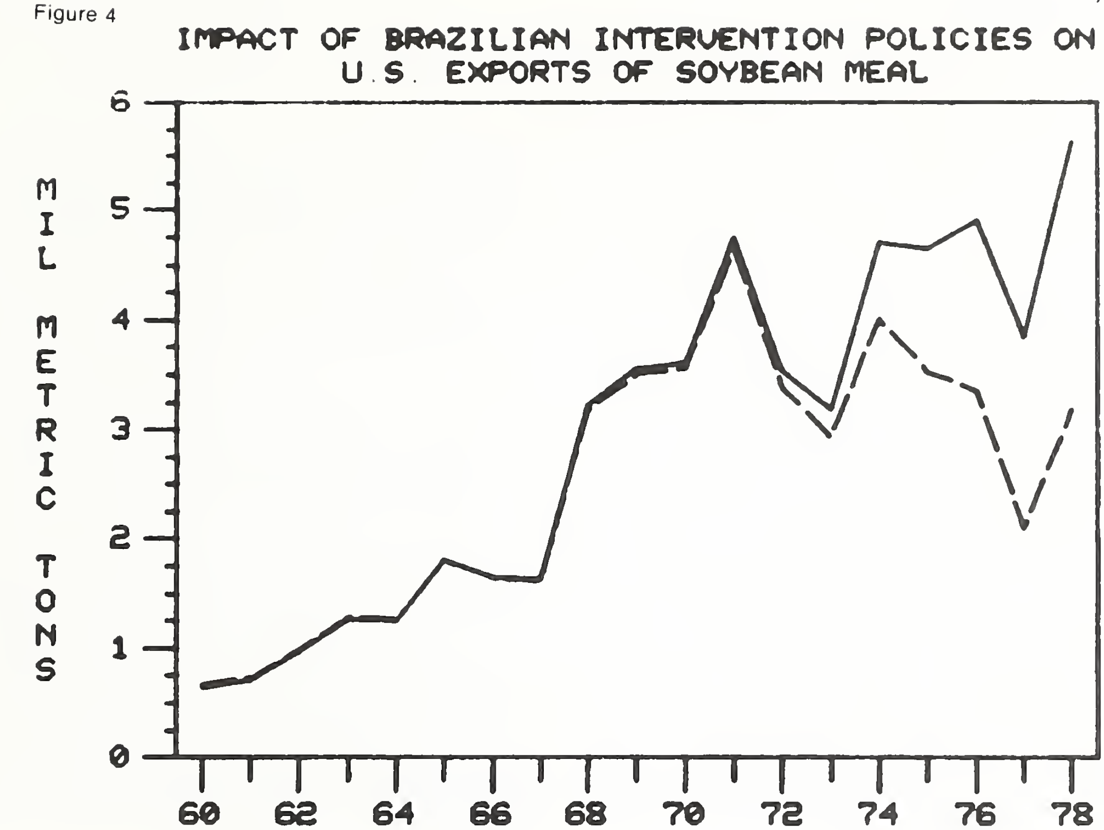
WITH INTERVENTION
WITHOUT INTERVENTION

Figure 4


IMPACT OF BRAZILIAN INTERVENTION POLICIES ON
U.S. EXPORTS OF SOYBEAN MEAL
MIL METRIC TONS
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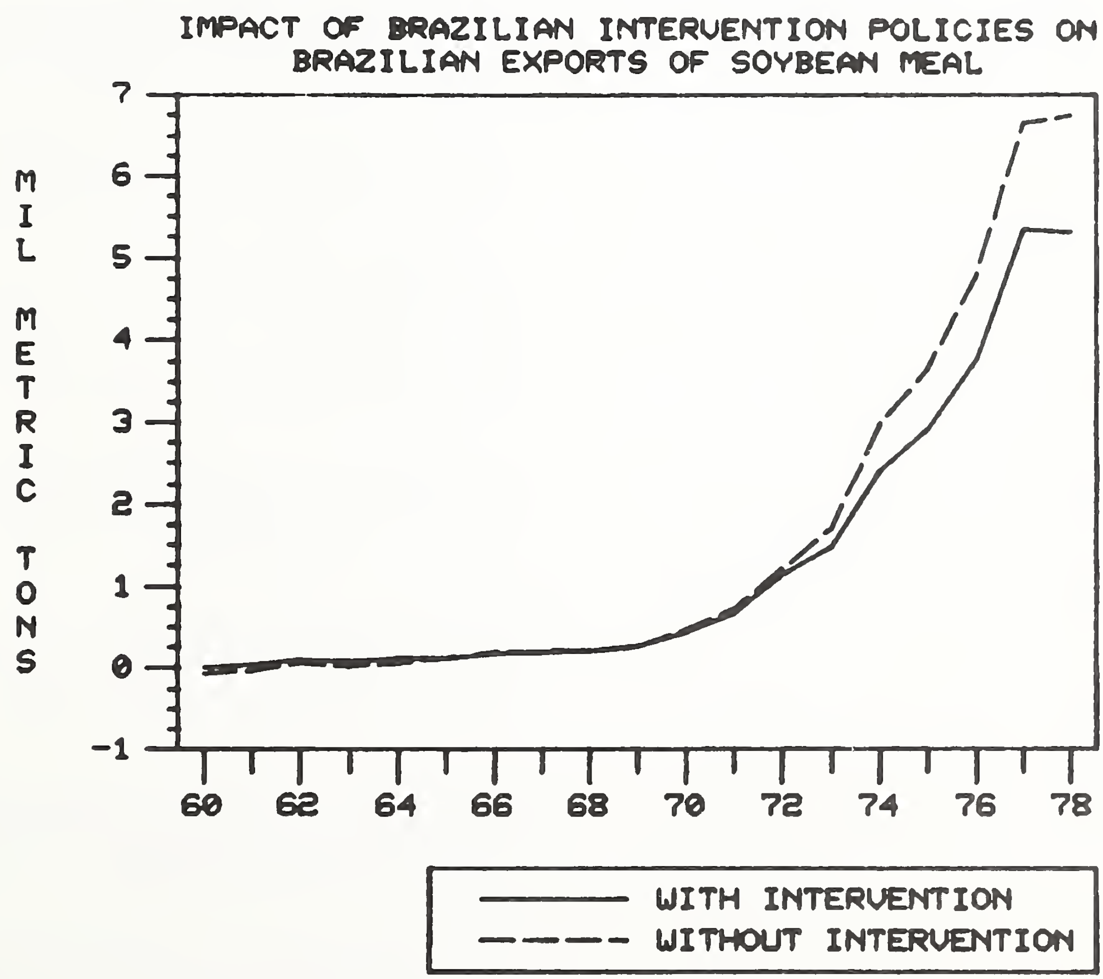
IMPACT OF BRAZILIAN INTERVENTION POLICIES ON
BRAZILIAN EXPORTS OF SOYBEAN MEAL
MIL METRIC TONS
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WITH INTERVENTION
WITHOUT INTERVENTION

- The Brazilian policies resulted largely in a change in the source rather than in the volume of soybean oil and meal supplied to the world market. The policies resulted both in a change of source and a lower volume of soybeans supplied to the world market;

- The Federation of EC Seed Crushers and Oil Processors applied in 1977 for protection "against imports of Brazilian soybean meal because of the indirect bounties and subsidies which are applied for the benefit of Brazilian exports" *(4)*. The simulation results suggest that although EC imports of soybean meal were larger in the seventies as a result of the Brazilian policies, the additional supplies on the market were of U.S. and not of Brazilian origin. Obviously, the export of Brazilian soybean meal would have been smaller in the absence of the "indirect. . . subsidies." However, the stimulative effects of the "indirect. . . subsidies" on Brazilian soybean meal exports were largely nullified by the dynamic restrictions on domestic crush and soybean meal supplies from Government intervention in its soybean market.

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